

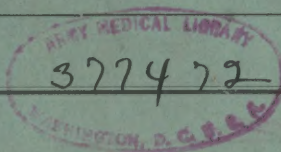
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Proceedings of the Congress  
OF  
C.M.F. <sup>Central Forces</sup> Army Surgeons

ROME

12th to 19th February, 1945



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Surgeons, Rome, 1945

PROCEEDINGS OF THE CONGRESS  
OF  
C.M.F. ARMY SURGEONS

ROME 1945,

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Journal of C.M.I. Army Surgeons, Rome, 1945  
Proceedings

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## Editorial Note

*The discussions following the papers are recorded more or less as they were taken down by stenographers at the time the words were spoken. Very little editing has been done, except where there was some doubt as to the speaker's exact meaning. To have asked each partaker in the discussion to edit his own contribution would have been a physical impossibility — all returned to their stations, some of which were overseas, after the Congress was over — unless one was prepared to delay publication of the proceedings indefinitely. My apologies are therefore given in advance should any of the views of the partakers in the discussion be misrepresented.*

*My thanks are due to Lt.-Col. A. J. C. Latchmore, M.B.E., R.A.M.C., for help with the collection and editing of the papers, and to Sgt. J. D. Wade, for the immense amount of clerical work he has done in the preparation of these proceedings for publication.*

HAROLD C. EDWARDS, Brigadier,  
Consulting Surgeon, A.F.H.Q.



# Programme

Monday, 12<sup>th</sup> February, 1945

## MORNING SESSION

### ASSEMBLY

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O.B.E, M.C., K.H.S., Director of Medical Services, Allied  
Force Headquarters*

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Closing Address By Major-General M. C. STAYER, Surgeon, MTOUSA

## Demonstrations

The following demonstrations and exhibitions were held in the Eastman Dental Clinic:—

- “Brain Wounds in Pictures”—Lt.-Col. P. B. Ascroft, RAMC.
- “Late Repair of Skull Defects”—No. 4 Maxillo-Facial Surgical Unit (O.C., Major P. Clarkson, RAMC).
- “Transfusion Stand”—Major Simpson, SAMC.
- “Illustrations of War Wounds in Colour”—Pte M. Suart, RAMC.

The following demonstration was held on Tuesday, 13th February, and Wednesday, 14th February:—

- “The Manufacture and Repair of Surgical Instruments”—Capt. A. Waltho, REME, O.C., 620 Medical Equipment Workshop.  
(By permission of Major-General W. S. Tope, D.M.E., A.F.H.Q.)

## Clinical Ward Rounds

Demonstrations of Genito-Urinary cases (Lt.-Col. D. S. Poole-Wilson, RAMC) and of Orthopaedic cases (No. 16 Orthopaedic Centre—O.C., Major Barbara Stimson) in the wards of No. 104 (Br) General Hospital were given on Thursday and Friday at 17.00 hrs.

# Congress of C.M.F. Army Surgeons

*held at*

Eastman Dental Clinic, Viale Regina Margherita, ROME

**Monday 12th February, 1945**

*Opening address by Major-General W.C. Hartgill, C.B., O.B.E., M.C., K.H.S.,  
Director of Medical Services, Allied Force Headquarters.*

"Before opening this congress, let me say that we have a full day before us, and I intend to say as little as possible.

There are just one or two things I would like to mention. First of all I want to extend a genuinely hearty welcome to our visitors. Unfortunately, certain visitors we expected from overseas have not yet arrived. It is very unfortunate, because this first day as you will see from the programme is a very important one, and I think some of the people who have not seen surgery at the front would profit from it, and, I think, would also have a lot to say. However, I expect they will arrive as the conference goes on.

I would like to say specially how sorry I am that Major-General Stayer, my opposite number, is not able to be present this morning. He came up to do so, but was recalled on duty last night. However, he will be here before we finish.

Another welcome I would like to extend, is to all our colleagues in this theatre, especially those in the American Army, our Allies, and Dominions. I don't think in this war there has been a congress where we have had assembled together such a brilliant galaxy of surgical talent, and by that I mean the surgeon with war experience who has done the job, and I believe you will find this conference will produce very good results. On that same subject I would like to say that in this theatre we have regarded ourselves as all part of one team, and I think the team work has been as good here as in any similar command. As I just mentioned, we have large numbers of Allies and people from all parts of the world and Empire, and everywhere we have had exactly the same results. We have all been kicking the ball at the same goal. You will find patients of all types intermingled in our forward units receiving exactly the same treatment, and it is only when evacuated down to base that they are drafted out to their own respective hospitals. Everywhere you will find the same feeling among these patients, and all of them paying the greatest tribute to the hospitals in which they were treated.

Many of you know that I was chairman of the committee which inaugurated the modern set-up in the field, which was designed to make surgery flexible in its organisation. It has been realised that on many occasions with the old set-up we could not get the wounded man back sufficiently early to the surgeon. We wanted an organisation which would bring the surgeon up to the wounded man. That organisation has stood the test. Everywhere we have been able to get first-class surgery forward and also post-operative nursing, which is almost equally important. It is most unfortunate when the surgeon does a good piece of work and finds that a man dies from lack of proper post-operative care. I think we have got it in this theatre. I am interested to hear that the same thing is going on in North West Europe. They are working under different conditions, but achieving the same results.

This is all I have to say by way of opening. I would like to take this opportunity to thank you all for the grand work you have done, and I hope you will go on making surgical history in the way you have been doing."





Monday 12<sup>th</sup> February, 1945

**Subject:**

**The Treatment of War Wounds**

*Presiding:*

Brigadier Harold C. Edwards, Consulting Surgeon

*AFHQ*





# THE PRIMARY OPERATION IN BATTLE WOUNDS OF THE LIMBS

by

Major H. W. BURGE, RAMC

General Hartgill, Brigadier Edwards, Ladies and Gentlemen.

I wish to discuss a few aspects only of the primary operation in battle wounds of the limbs.

## Pre-Operative Preparation of the Skin

Always first and not unimportant is the proper preparation of the skin; and by this I mean nothing more and nothing less than the wide use of soap, water and the razor. More than ever is this important now that delayed primary suture is our aim. To make the wound safe for life is not enough; we must make it too, safe for successful suture.

In Africa, in our advanced surgical centres, it was usual for the fully dressed and therefore inadequately examined and improperly X-rayed patient to be placed on our operating tables. Too much, far too much, time was spent examining and undressing and to undress the unconscious patient is, in itself, a difficult and slow undertaking.

Since then we have travelled far, and now, in our Advanced Surgical Centres, we are given, usually, the stripped, examined, recorded and X-rayed patient. Yet I think it is fair to say that there is still room for considerable improvement. It is not because we surgeons do not realise what should be done; rather is it because, in time of battle, there is so much to be done in so short a time. How then can we improve? We can improve by washing and shaving the limb, not in the theatre, but in the pre-operative ward. Here patients must wait for operation; here then let them be washed and shaved. It can be done by the properly masked orderly, be he British or Italian, soldier or civilian, and done too in the majority of battle casualties.

I want to advise the use of the washing and shaving bench in the pre-operative wards of all our Advanced Surgical Centres.

## Radiology

It is interesting to review the change of feeling over the last two years towards radiology in advanced battle surgery. Then, in Africa, the feeling of most forward surgeons was that X-ray help was not necessary in trunk and limb surgery and was, perhaps, a waste of time.

I need not discuss its value now in thoracic, abdominal and thoraco-abdominal injuries; we are all agreed that such surgery is undesirable without it. Rather I do want to stress its value in limb surgery. I agree that it is not important to know the position and nature of bony injury; these will be seen if the wound is properly explored. But the value of the removal of the metallic foreign body has not been fully realised. Now that delayed primary suture is in general use, more than ever is removal necessary; where the metallic foreign body is, there also is the battle-dress and if we fail to remove the metal we fail also to remove the cloth. The easiest way to find these foreign bodies is by the enquiring finger in the track when it is most easy to follow at the time of the first operation. We want these foreign bodies out, especially in fracture cases, before suture is done.

## Radical—"To be or not to be"

You will remember that in Africa two armies met; one came from the east and one from the west, and, it is true that they met a little more to the west than to the east, but they differed, so they thought, in the primary treatment of wounds. They agreed on the value of decompression, but disagreed on the extent of muscle excision. Later, gentlemen, they met on common soil, the common, dirty soil of Italy and on this dirty soil they came to practise the same operation — the same operation because that great principle of wound surgery is not new and has not changed, and I think will not change — to remove the bad and to leave the good.

The future is clear — to apply this simple principle to all war wounds no matter where we are or what these wounds are like, but especially must we be thorough in debridement now that delayed primary suture is to follow.

## The Principles of Wound Treatment

1. Adequate decompression.
2. Thorough debridement.
3. Fixation for evacuation.

These are the principles; I need not enlarge much on them but I would stress the value of decompression. Subnormal tension in the tissues must be our aim. For all wounds are infected, and tension means avascular muscle, and this leads to sepsis, and sepsis means inflammation and tension. A vicious circle — and was there ever a circle more vicious than this?

But there is now a new and fourth principle — preparation for delayed primary suture. The ideal delayed primary suture consists of nothing more than insertion of skin sutures. Often, mobilisation of skin is required and if this is done at the delayed primary suture there is hæmorrhage — which is always to be avoided, if possible, in this operation. I want to see the surgeon at the initial operation, mobilise skin, test for tension — do, in fact, the first part of the delayed primary suture. This does not lead to sepsis, certainly not in the early, well-debrided wound.

## The Treatment of Skin, Fat and Fascia

The importance of longitudinal skin incision and the use of the double longitudinal incision in T & T wounds is well recognised. As a general rule the skin edge should be left and tags only removed, unless there can be no question of tension at the delayed primary suture — then deliberate skin excision is justifiable, and then only if delayed primary suture is assured.

If an early wound is properly debrided and the skin, with its fat, allowed to fall back in position then at delayed primary suture the flaps can be raised and will show clean surfaces. If the wound is old, with established sepsis, then no matter how good the debridement that wound at four days will not be clean. In this case I sew back the skin flaps over a thick gauze roll and apply penicillin calcium. On the fourth day the sutures are cut and delayed

primary suture performed. I use this method too, and have been well pleased with it, in amputations, but do not advise evacuation afterwards. It is a good method where the surgeon can handle the case throughout.

When the fat is "dirty" at the skin margin, to excise it is to leave there skin only. At delayed primary suture later, skin to skin alone will not heal well. In these cases I sew back the skin flaps and leave the dirty fat which is treated with penicillin calcium. Successful delayed primary suture can often be expected, especially when tension is absent.

### Bone

We are taught to remove all dead and potentially dead tissue — to remove all completely detached bone fragments. All surgeons who have dealt with fractures caused by high velocity metallic foreign bodies will know that completely detached fragments are the rule. With this teaching I agree in penetrating wounds of the head with fracture of the skull; I agree in open wounds of the chest with fracture of the ribs; but I *do not agree* in fractures of the long bones of the limbs. To remove these fragments leaves a gap and, while it is true that new bone can

sometimes jump a gap, it may fail and more trouble is caused by removal than ever was by leaving these fragments in position. Sequestration, I believe, is rare and, in properly debrided and decompressed wounds these fragments fuse into sound bony union.

Gentlemen, graft your fractures with completely detached fragments.

### The Proper Control of Pre-Operative Evacuation

This is the last and an important point I wish to make, for on this evacuation depends the thoroughness of the primary operation. If wounded men are allowed to accumulate in the pre-operative ward of an Advanced Surgical Centre their number will far exceed the working capacity of the theatres. Hurried and bad surgery will be encouraged and the time-lag between injury and operation will be increased. Good liaison between units regarding pre-operative evacuation can do much to ease the burden on the forward surgeon and cut down this time lag which is so important. Especially is controlled pre-operative evacuation necessary at C.C.S. level where so many low priority cases do collect. This principle has been latterly realised and practised and is one of the many things for which we forward surgeons must thank Brigadier Stammers.

## THE PRIMARY TREATMENT OF WOUNDS

by

Major G. H. WOOLER, RAMC

I am going to restrict myself to wounds involving muscle only.

I am not going to describe the treatment of other injuries which are detailed for discussion later.

When a wounded man is admitted into the operating theatre examine his field medical card and question him about his injuries, for occasionally he will tell you about one which has not been noted on his card.

Then inspect his injury, and if it is in a limb, feel for arterial pulsation distal to it. Compare the temperature with the opposite limb and test for nerve lesions.

If there is just an entry wound ask him where he has the most pain; he may point to where the foreign body is lying. In any case inspect the other side of the limb yourself, for F.Bs. frequently come to rest under the skin.

Removal of the dressing may require an anaesthetic. A gauze pad soaked in aqueous acriflavine solution is placed on the wound while the surrounding skin is shaved and cleaned with soap and water. Too much soap and hot water cannot be used for this purpose. It takes two orderlies to clean a limb, one holding it carefully while the other washes and shaves.

The pad is removed from the wound. The skin is painted with flavine in spirit and towels are put round.

As a general rule and with very few exceptions I explore all wounds.

Each case must be judged individually and when dealing *with multiple injuries* the great thing is to do the most important ones first, and take a chance with the others, doing only what is essential to these such as splitting the deep fascia, rather than to subject the patient to a long operation. Do the most important wounds in the correct sequence so that the patient is moved as little as possible during the operation, because all movements worsen his general condition and lessen the time you can spend operating.

The time spent over the operation is an important factor, for the patient will stand a certain amount and no more. You have got to decide what to do during this period and then stop, otherwise the length of the operation alone may kill the patient.

If after excising one or two wounds his general condition has deteriorated considerably, and there are other wounds still requiring attention — stop operating, tip up the table, cover him with blankets, give blood and oxygen and leave him for half an hour while you deal with another case on your second operating table. After this time he will have recovered sufficiently for you to carry on, but you must work fast, for every minute counts.

I commence excision of a limb wound by enlarging it a little in the long axis; then by applying tissue forceps to avert the skin edges I excise the track through the subcutaneous fat liberally for it always contains a considerable amount of dirt. I leave the skin alone except to remove small tags which are obviously devitalised.



I open up the deep fascia in the long axis of the limb, and it is the amount of damage to the deep fascia which determines how long the incisions have to be made, but do not be afraid to make them long enough, they should always reach to the full extent of the skin incision. I never hesitate to open up the full length of the calf or thigh if I consider it is necessary, and when dealing with the fascia lata of the thigh transverse incisions are required as well, in order to decompress the muscle adequately.

Avoid transverse incisions around a limb. Where the track crosses from lateral to medial aspect it should be followed from the lateral aspect as far as possible. Then a counter incision made on the medial side and the pursuit continued.

Avoid incision over bone where the resulting scar has a chance to become adherent and painful. If there are several wounds on one side of a limb with considerable underlying muscle damage, I join the wounds together even though the resulting incision is rather 'S' shaped. It enables you to open up the deep fascia more fully than if you excise each wound separately.

Very small tracks involving only muscle I follow as far as possible, but would not conduct a long search for a small F.B. which in all probability will not give any trouble.

I follow the track by vision rather than by palpation, excising damaged fascia and all muscle which will not contract or bleed.

I think the most difficult wounds to deal with are those caused by blast where large lumps of earth have been blown into the tissues. They are full of nooks and crannies containing dirt, and each one has to be opened and excised.

When dealing with dirty wounds I irrigate gently with aqueous flavine solution which washes away most of the dirt — although care must be taken not to push it more deeply into the tissues.

A good light is essential, preferably a spot light, and after removing the F.B. carefully inspect the bed in which it was lying, for nearly always pieces of clothing will have been taken in as well.

Sometimes the track does not end here but leads to another F.B. lying more deeply.

The size of the entry wounds may be misleading and bear no relationship to the amount of underlying muscle damage or to the size of the F.B. It is impossible to assess the amount of muscle damage from the external appearance of the wound. The elasticity of the skin must be responsible for the fact that I have on occasions removed an F.B. of twice the diameter of the entry wound through which it has passed.

The aim of the surgeon is to produce as aseptic a wound as possible, to allow room for the muscle to swell, and to provide adequate drainage. Serum and blood are going to ooze from the surface of the wound during the subsequent 2 or 3 days depending upon how successful you have been in producing hæmostasis. I tie off all bleeding points with thread for I find it easier to work with than catgut, and so far as I know it has not given any trouble subsequently.

Divided tendons or nerves I leave completely alone.

The well excised wound should allow any small collection of fluid to drain out of it while patient is lying on a stretcher or in bed.

This is most difficult to obtain on the anterior aspect of the thigh. When the limb is elevated blood and serum collect in the upper part of the wound from where it is impossible to drain. I usually make a counter incision on either the medial or lateral side of the thigh, which ever is nearer to the track, and open up the deeper part of the wound through this incision. How long it keeps open I do not know. I did consider putting a rubber drain through in certain cases but so far have not had the courage to do this.

Most buttock wounds require an X-ray examination of the abdomen, rectal examination and the collection of a specimen of urine. I frequently open up the track completely for a through and through wound of the buttock when this does not entail dividing thick muscle. I think this is a wise procedure because the amount of muscular damage to the glutei lying between small entry and exit wounds has surprised me and this is impossible to excise without opening the whole track.

Dirt and clothing hide themselves away between the coarse muscle fibres and cannot be seen without an adequate exposure. It also enables you to see injuries to the superior and inferior gluteal vessels which are not uncommon, and torn arteries may be pulsating but not bleeding at the time of excision.

I have never yet performed a colostomy for wounds near the anal margin but have evacuated such a case to a centre where delayed primary suture could be performed as soon as possible.

While excising entry wounds of the buttock you may find the track going through the iliac bone and if you have previously decided that it was probably not a penetrating abdominal injury access to the pelvis can be obtained through an oblique incision about two inches medial to the anterior superior iliac spine. It is an extraperitoneal approach and few muscle fibres need to be divided but it enables you to follow the track after it has entered the pelvis — giving you an excellent view of the contents and of the internal iliac vessels if they require ligation.

### *Hands and Feet*

Injuries of the hands and feet require the minimum amount of surgery and only enough need be done to produce a clean wound; but protruding sharp ends of metacarpals or phalanges should be trimmed so that they are smooth and easily covered with skin.

Remember that the thumb is the most important digit and preserve as much of it as possible.

I never suture divided tendons or put in any skin sutures. A difficult skin flap I would try to hold in position by the dressings alone.

### *Amputations*

Apart from traumatic amputations the two main indications for performing a primary amputation are to save the patient's life and to remove a useless limb.

When a patient is admitted to the theatre with only limb injuries — a clue to the possibility that he may require amputation is a message from the field transfusion officer stating that he has not responded well to resuscitation. With limb injuries, after hæmorrhage has been controlled, this failure of response may be due either to gross trauma pulp- ing muscle or to gas gangrene.



If in spite of resuscitation he is going downhill I put on a tourniquet just above the wound excluding the damaged tissues from the rest of the body. Such a case has improved sufficiently to perform amputation proximal to the tourniquet, and after the operation when I have examined the limb there has always been a great deal of muscle damage or evidence of anærobic infection.

Unless it is unavoidable I would never amputate an arm at the first operation. The main deciding factor being the amount of damage to the brachial nerve plexus. Even if there has been extensive damage to an arm I would try to patch it up and give it a chance, for it can be amputated later.

The patient may stand your fixing up his arm but if he has a leg injury as well he may not stand a second lengthy excision. The loss of a leg does not matter so much. I usually leave leg injuries to the last so that if his general condition has already been exhausted while you have been dealing with an associated abdominal, chest or arm injury you can either amputate, or excise the leg wound, whichever produces the less trauma. A through knee amputation is the quickest and least traumatic one to perform.

After excising a wound, penicillin powder is applied commencing in the deepest part; — muscles and tendons need to be retracted to ensure that the powder reaches all over the wound. Then put on

either one layer of vaseline gauze followed by dry gauze, or dry gauze alone. These must never be allowed to encircle the limb and if there are wounds on each side care must be taken to leave gaps between the gauze dressings. Wool can then be wrapped round from a roll, followed by a plaster cast. Nothing under the plaster must encircle the limb other than cotton wool.

The two best weapons for fixation are plaster of Paris and the Thomas splint. The only time I use Cramer's wire is in the form of an arch over the hand or foot to prevent the pressure of blankets.

For muscle wounds of the forearm I apply either a thin plaster cast or a P.O.P. slab which fixes the wrist in dorsiflexion.

Muscle wounds of the arm and shoulder — bandage arm to the chest with 2 flannelette bandages and a few plaster bandages over them to keep them in position.

Muscle wounds of the leg — I put on a below knee P.O.P.

Muscle wounds of the thigh — Thomas splint, but if they are associated with a large buttock wound, I cut off the ring from a Thomas' splint, attach the two lateral bars to a plaster shell for him to sit in. His limb rests on the remains of the Thomas' splint and both buttocks fit into the plaster shell which is fixed round his pelvis with a many-tail binder.

## DELAYED PRIMARY SUTURE OF FLESH WOUNDS

by

Lt. Col. C. J. B. MURRAY, RAMC

The problem of treating flesh wounds at the base hospital level really resolves itself into two things:—

- (1) Getting the wound closed as soon as possible,
- and
- (2) Preventing wounds, which arrive clean, from becoming infected before this can be done.

All wounds however small or apparently unimportant should be sutured if this is mechanically possible, as the end result in a successfully sutured wound is incomparably better than in one which has been allowed to heal by granulation. A linear non-adherent scar is produced, fibrous tissue formation is reduced to the minimum and ward dressings and chronic sepsis almost eliminated. The period of hospitalisation is reduced by 50%-60%, and the chances of a man returning to category A duties very much better.

**The Results** of the operation are good and in a series of 729 wounds sutured in my division by five different surgeons have been as follows:—

Method	Total Wounds Sutured	Successful (100 % — 90%)	Failed. (90 % — 0 %)
Suture and Penicillin.	500	458 (91 %)	42
Suture and Proflavine	229	174 (75 %)	55
Totals	729	632 (85 %)	97

These were flesh wounds uncomplicated by major compound fractures. In assessing the results, 100% healing has been taken to indicate a completely dry healed wound when the stitches were removed. Cases where the wound, although healed by the 12th day have shown some inflammatory reaction, moistness and infection round the stitches have been classified as 90%.

There was one death in the series. This occurred in a German P.O.W. who had been successfully treated for gas gangrene. There was a large clean wound on the opposite thigh which was sutured over penicillin powder. Two days later he developed a fulminating B. Welchii infection and died. In spite of a negative swab before operation the infection had obviously been present in the wound and had been stirred up by the operation.

### Routine Adopted

The routine we have adopted has been to leave all cases for 24 hours after admission with the dressings undisturbed, unless there is some special indication for immediate interference.

The case is then prepared for anaesthesia and taken to the theatre where the dressings are removed and the wounds inspected and if considered suitable are sutured then and there.

I personally believe that the best time to perform delayed primary suture is between the fourth and sixth day. By that time the initial reaction in the

wound has settled down and at the same time the edges have not become fixed and granulation tissue has not started to form.

In this series of cases the decision that a wound was suitable for immediate suture was made on clinical rather than bacteriological grounds.

In the penicillin series, operation was postponed in 87 wounds (18%) which showed marked inflammation and oedema of the skin edges, gross infection, or which had deep infected pockets or tracks. In these cases the wounds were explored and any F.Bs. (particularly pieces of cloth) in the immediate vicinity of the wound removed, and if necessary efficient drainage established, and the wound dressed with penicillin powder and "tulle gras." This dressing is left for 48 hours after which the wound is once again reviewed in the theatre and if necessary again dressed in the same way.

In cases with deep pockets or tracks, penicillin tubes inserted into the depths of the wound have been used instead of powder and twice daily instillations given in the usual way, for three days, at the end of which time the wounds have been sutured with the penicillin tubes still *in situ* and instillations continued for a further five days.

### The Operation

The actual operative technique has varied in these cases depending on whether the case has been one of delayed primary or secondary suture.

In delayed primary suture the wound edges are first freed and re-excised together with any devitalised fat, and the wound then carefully examined for deep tracks or pockets with a view to deciding whether to employ the penicillin in powder form or as an installation through one or more tubes. If tracks or pockets are present or if any dead space is likely to be left after suture, tubes should be used and these should invariably be brought out through separate stab incision at least two inches from the wound margin.

An estimate of the degree of tension required to approximate the wound edges is now made, and the edges undercut or a flap swung to reduce this to the minimum. A certain amount of tension seems inevitable in the majority of cases but provided it is not excessive does not seem to interfere with healing.

Complete hæmostasis is I think of fundamental importance, and in this connection I think that the boggy of leaving a few fine catgut ligatures in these wounds is greatly overrated and seems to me preferable to a hæmatoma which is usually disastrous.

All parts of the wound are now thoroughly dusted with penicillin powder, which is then gently rubbed round with the finger, and the skin closed with fairly closely set Everson stitches.

A dry dressing held in place, with firm pressure, by elastoplast or a crepe bandage completes the operation.

Immobilization in plaster has not been used as a routine.

In secondary suture — the operation is virtually the same, except that the whole wound including granulation tissue and any underlying fibrous tissue is re-excised.

This type constituted 12% of the whole series and of these 73% were successful.

### Post-operative Treatment

As far as possible these cases should be segregated in special wards and not nursed alongside patients with open wounds. Apart from this the treatment is simple, the patient merely being confined to bed and the dressing left undisturbed until the fifth day when the wound is inspected once again in the theatre, and any excessively tight or moist stitches removed.

I think this is an important point and by removing a few offending stitches at this juncture a wound which would otherwise break down can be saved. The dressing is then left undisturbed until the 10th or 12th day when the sutures are removed, and exercises commenced the day after. The patient is normally allowed up on the 13th or 14th day, and in straightforward cases should be fit for transfer to the convalescent depot seven to ten days later.

### Cases with Excessive Skin Loss

There will always be a number of cases in which complete suture is not possible owing to excessive loss of skin. In practice the number has proved to be much smaller than was expected.

These cases have been dealt with by partial suture followed by skin grafting about 14 days later.

### Bacteriostatics

There now seems to be no doubt whatever that penicillin is the bacteriostatic of choice, and this is now used as a routine on every case, either as the powder in a strength of 1000 units to the gram or by instillation in the strength of 500 units to the cc — 3 to 5 cc's being instilled into each tube twice daily for 5-8 days.

In this series, 229 wounds were sutured over 1% proflavine and sulphanilamide powder. The results were disappointing compared with the penicillin series — 75% only being successful, this figure being comparable with published results in cases sutured over sulphanilamide powder alone.

### To Summarise

The success of delayed primary suture depends on the prevention of infection, and this is best achieved by:—

- (1) Early and adequate forward surgery.
- (2) Non-interference with dressing between the forward operating theatre and the base hospital theatre.
- (3) Early closure of the wound using penicillin.
- (4) Elimination of post-operative ward dressings.

In Conclusion one would like to pay tribute to the very high standard of work maintained by the forward surgeons. The credit for the success of the "two stage operation" is really theirs.

### Brigadier Edwards:

I would like to add my tribute to the work of the forward surgeons. In late 1917 to 18 a great deal of delayed primary suture was being done, and here we are back, in what we hope to be the closing phases of this war, treating wounds in the same way. I would like also to pay tribute to the administrative authorities who have done their utmost to make evacuation as smooth as they possibly could to avoid delay between the forward surgeon and the base.



# SYNOPSIS OF THE RESULTS OF TREATMENT OF 288 CASES OF OPEN FRACTURE OF THE FEMORAL SHAFT.

Feb. 1944 to Jan. 1945

by

Major R. FURLONG, RAMC

A year ago the 17th Orthopaedic Centre began to admit a large number of patients with fractures of the femur and at that time adequate supplies of penicillin became available so an investigation of the results of treatment was begun. An interim report was made in May 1944 and a synopsis of the final report is incorporated in the accompanying table.

An unbiased and judicial enquiry has been carried out with a view to assessing the results obtained by different methods of treatment of the soft part injury. The investigation was concerned with the evaluation of the results obtained by various surgical procedures and not only to determine the value of penicillin, as such, in the treatment of this group of patients.

The patients in this series have been selected on the following criteria. The patient must have an open fracture of the femur, a small number of non-battle casualties have been included, and the site of the fracture is between the supracondylar level and the trochanteric region. All such patients admitted during the year under review have been included. Certain terms used in the table require explanation.

## Definitions

**HEALED.** By this is meant complete epithelialization of a wound whether it has been previously sutured or not.

**BONE SHUT OFF.** This represents an ulcer of any size from a large granulating area to a small moisture of a wound. By all clinical tests available this area is shut off from bone and is, in fact, not a sinus. It is realised that sometimes it is difficult to be sure that such an ulcer does not communicate with bone and if doubt exists it has been assumed that a sinus is present.

**SUMPS.** This is a collection of pus in the thigh usually between the muscles. Some drainage may exist but usually this is inadequate. Such an abscess is always in relation to the fracture site though it may have tracked some distance up the thigh.

## The Control Series

In this table the significant figures are in the "bone shut off" column both at the eight and twelve week period. It will be seen that there is little improvement in the chronic sepsis rate between the eight and twelve weeks. Slight improvement is only to be expected, however.

### Control Series of 70 Cases Treated Without Penicillin

#### NO CLOSURE

##### 8 WEEKS' REVIEW — 58 CASES

Healed . . . . .	6	10 %
Bone shut off . . . . .	38	65 %
Sumps. . . . .	5	8.6 %

##### 12 WEEKS' REVIEW — 58 CASES

Healed . . . . .	8	14 %
Bone shut off . . . . .	39	67 %
Sumps. . . . .	5	8.6 %

##### CONTROL SERIES — 70 CASES

Mortality Rate . . . . .	6	8.5 %
Amputation Rate . . . . .	6	8.5 %
Secondary Haemorrhage Rate . . . . .	2	2.8 %

This series of patients was treated by limited secondary trimming, if necessary, but there was no suture of the wound. The initial dressing applied in the theatre was left undisturbed as long as possible but it was changed if necessary. That is to say if a dressing was soaked with pus it was changed with the usual precautions available in a ward. The mortality rate and amputation rate are of significance when compared with those of the penicillin series. It is thought that the figures for the control series represent the average results of treatment when patients receive no penicillin and are received in a base hospital up to ten days from wounding. These figures formed a base line to be improved upon.

## The Penicillin Series

All patients in this series were treated with intramuscular penicillin from the time of their definitive surgery. On an average this was done at seven days from wounding and the average course of penicillin given was 750,000 Units. If necessary, a limited trimming of the wound was done at the time of setting up of the fracture and then the wound was treated by one of three methods depending on the type of wound, the amount of skin loss, etc.

### Series of 218 Cases Treated With Penicillin

#### PARTIAL CLOSURE — 103 CASES

##### 8 WEEKS' REVIEW — 94 CASES

Healed . . . . .	13	14 %
Bone shut off . . . . .	53	56 %
Sumps. . . . .	11	12 %

##### 12 WEEKS' REVIEW — 92 CASES

Healed . . . . .	24	26 %
Bone shut off . . . . .	56	60 %
Sumps . . . . .	2	2 %

#### DRAINAGE — 65 CASES

##### 8 WEEKS' REVIEW — 63 CASES

Healed . . . . .	27	43 %
Bone shut off . . . . .	44	70 %
Sumps . . . . .	1	—



## 12 WEEKS' REVIEW — 63 CASES

Healed . . . . .	31	49 %
Bone shut off . . . . .	49	78 %
Sumps . . . . .	1	—

## COMPLETE SUTURE — 45 CASES

## 8 WEEKS' REVIEW — 38 CASES

Healed . . . . .	20	53 %
Bone shut off . . . . .	33	87 %
Sumps . . . . .	1	—

## 12 WEEKS' REVIEW — 36 CASES

Healed . . . . .	23	64 %
Bone shut off . . . . .	31	86 %
Sumps . . . . .	0	—

## PENICILLIN SERIES — 218 CASES

Mortality Rate . . . . .	6	2.7 %
Amputation Rate . . . . .	8	3.7 %
Secondary Hæmorrhage Rate . . . . .	8	3.7 %

**PARTIAL CLOSURE.** Initially a partial wound closure was performed, that is, the ends of the wounds were sutured to support granulations but a large central area was left open to allow of drainage, though no fresh communication with the interior of the wound was made. As a routine practice the dressings that were applied in the theatre were not disturbed for three weeks.

It will be seen that the results for "bone shut off" at eight and twelve weeks showed a deterioration from those patients treated without penicillin. It is thought that the poor results were because penicillin merely suppressed pyogenic organisms whilst it was being given, usually for six days, and after that time pathogens, particularly staphylococcus aureus, once more flourished in the wound which was continually being re-infected from the dressing. The wound was, in fact being poulticed with staphylococci. To overcome this efforts at drainage of the depths of the wound were made in order to liberate the products of inflammation.

**DRAINAGE.** In this series of patients the wounds were trimmed if necessary and then sutured completely with a large bore rubber tube inserted posteriorly to the fracture site through an original wound if present or a separate stab wound if necessary. The fracture was set up in the same manner and the rubber tube drained either into dressings or into a porringer in the bed. The tube was removed on the fifth day.

It will be seen that the eight and twelve week results were improved. By partial closure 56% of patients had "bone shut off" at eight weeks, whereas when a drain was used 70% had "bone shut off." The same type of improvement is present at twelve weeks for whereas by partial closure 60% had "bone shut off," by drainage 78% were in a similar state. The improvement obtained by drainage was not considered sufficient and it was felt that the best way to prevent chronic bone infection was to convert the open fracture into a closed one by complete skin suture at the earliest possible moment.

Obviously careful selection of cases for this method had to be made if sumps were to be prevented. Therefore, at first, complete suture was only performed in those patients with muscle damage no greater than that caused by a bullet. Later more severely injured thighs were sewn up provided "tentage" could be avoided.

**COMPLETE SUTURE.** In this series all wounds completely sutured without local drainage. Not all of the wounds remained dry but in those that broke down usually only an ulcer was formed and not a sinus. It will be seen that at eight weeks 87% of these cases had "bone shut off" and at twelve weeks the percentage was the same. There was no greater incidence of sumps in patients treated by this method, probably due to careful selection.

It is thought that there is a place in the treatment of open fractures of the femur for all three methods. There are some patients in whom only a partial closure is possible because of great skin loss. Equally, drainage is appropriate in some cases when the skin can be sutured but where there has been muscle loss leading to the formation of a potential sump. And finally complete suture is desirable in all patients with sufficient skin to suture and in those whose muscle damage is moderate and not sufficient to disturb normal anatomy.

## Analysis of the Results of the Last 148 Cases — Penicillin Series

## 8 WEEKS' REVIEW — 134 CASES

Healed . . . . .	50	37 %
Bone shut off . . . . .	100	75 %
Sumps . . . . .	5	3.7 %

## 12 WEEKS' REVIEW — 130 CASES

Healed . . . . .	62	48 %
Bone shut off . . . . .	104	80 %
Sumps . . . . .	1	—

## METHODS OF TREATMENT

Partial Suture . . . . .	54	36 %
Drainage . . . . .	61	41 %
Complete Suture . . . . .	33	22 %

An analysis of the results of the last 148 cases who were treated by all three methods show that at eight weeks 75% of patients have "bone shut off" and that at twelve weeks 80% of patients have "bone shut off." These figures should be contrasted to those obtained in patients treated without penicillin, and it will be noted that the improvement in the results is from 65% at eight weeks, without penicillin, to 75% in those patients treated with penicillin. At twelve weeks the improvement is from 67% to 80%.

The improvement in the mortality and amputation rate in the penicillin series is marked and significant. In the last series of 148 cases the three methods of treatment were used in the following proportion:—

Partial suture . . . . .	36 %
Drainage . . . . .	41 %
Complete suture . . . . .	22 %

It is thought that the proportion of wounds completely sutured will increase at the expense of the other two methods as further experience is gained in the selection of suitable wounds. But it is felt that even when it is possible complete suture may not always be desirable. The production of a sump is a risk that will be increased if complete suture is done indiscriminately.

Throughout the investigation the assessment of the result has been based on whether the bone has been shut off rather than whether the skin has been soundly healed. Clearly it is desirable to have the skin soundly healed but, by definition the patients in the "bone shut off" class can readily be transferred to the healed class by skin grafting. The reason why re-surfacing has not been done earlier in the treatment is that objection is taken to moving the patient to the theatre during the course of treatment and thereby jeopardising the position of the fragments and the alignment of the fracture.

### Conclusions

- (1) It would seem that the value of penicillin in the treatment of this group of patients is established.
- (2) The best results have been obtained by complete wound suture at the time of definitive surgery.
- (3) There is a place for all three methods of treatment in this group of patients.
- (4) The proportion of patients in whom complete suture is advisable is not known.
- (5) The selection of patients for complete suture is difficult.

## WAR WOUNDS INVOLVING THE FEMUR

by

Major BARBARA STIMSON, RAMC

Delayed primary suture of war wounds with underlying femoral fractures is no longer an experiment. Satisfactory results have been reported from many centres and the patient with chronic sepsis, with draining, dirty wounds and osteomyelitis, has become a rarity. The time has come, I think, to discuss details and variations in technique and the reason for failure in those cases in which complete healing was not obtained.

The 16th Orthopaedic Centre had its first opportunity in May, 1944, at the time of the Cassino battle, of dealing with early wounds of the thigh involving the femur. Various methods were tried and there was much discussion with our general surgical colleagues. By trial and error we evolved a simple procedure which we had the occasion to put into effect during the months of October, November, and December.

The following table shows a comparison of the earlier period with the later:

**Compound Fractures of Femur**

	Total Cases	Sutured	Healed	Sinus	Gran Area
70 Gen Hosp. May-July	41	39	31	4	4
			80 %	20 %	
104 Gen Hosp. Oct.-Dec.	46	43*	38	4	—
			91 %	9 %	
Total	87	82	69	8	4
			86 %	14 %	

\* 1 death from hæmorrhage 4 days after suture

second it was used only where the condition of the patient and the wounds appeared to require it, in 7 out of 43 cases. Rubber drains were used in 8 cases in the early series. No drains were used in the latter series. Penicillin tubes for local instillation of sodium penicillin were employed 8 times in May, June, and July, 10 times from October through December.

The details of the procedure employed in the recent months are as follows. There is nothing new or original about them. On admission blood was given in almost every case and hæmatocrit determination made. The day after admission the patient was sent to the operating theatre via the X-ray department so that the wet films were available at the time of operation with the minimum moving of the patient. In the theatre, under pentothal anaesthesia, the tobruk was removed, the extremity thoroughly washed and shaved; the wounds were then inspected, carefully cleansed and all clots removed. Swabs wet with saline were found most efficacious for this purpose. Available F.Bs. were removed, the skin edges were then carefully separated by blunt dissection, the wound dried and calcium penicillin, sulphanilamide powder insufflated. If there was a tract of any length or if the wound was dirty, a penicillin tube was used. The skin was then sutured with large vertical mattress tension sutures and the edges approximated as carefully as possible with close interrupted sutures. It was found that moisture proof suture material, like nylon, gave the best results. Skin traction was then applied to the leg and fastened in the usual way to a Thomas Splint. Subsequently more blood was given as needed. On the fifth day following suture the patient was brought to the operating theatre for inspection of wounds. At this time penicillin tubes, if used, were removed; further approximation of skin performed, if necessary, and any cutting suture taken out. On the tenth day the patient was again taken to the theatre, this time via the X-ray department, the sutures were then removed and definitive treatment decided upon—skeletal traction, the use of the Australian or Hamilton

In the first group intramuscular penicillin was used almost routinely, in 37 out of 39 cases. In the



Russell type of traction, etc. In some cases, of course, a pin had to be inserted earlier if wounds of the leg prevented the use of skin traction. No wounds were inspected on the wards. Certain cases had some separation of the skin edges if there had been much loss of skin, and there was usually a granulating area at the site of a penicillin tube but these small areas were in most instances completely epithelialised in 4-6 weeks. Small Thiersch grafts were used if the areas seemed of sufficient size to warrant.

This sounds simple. Why did four cases of the series fail to heal? A brief analysis of the four may be of interest. The first was wounded by a shell 24/10/44. There was a delay in evacuation and he did not reach the operating theatre until 8/11/44, a 15-day lapse. There was a 7-inch clean lateral thigh wound and a 12-inch gaping wound on the medial side of thigh and knee with loss of muscle and the entire medial femoral condyle. This wound was dirty. The lateral wound sutured. The medial wound was sutured after two penicillin tubes had been inserted into the cavity. The patient was given 500,000 units of penicillin intramuscularly. His general condition improved steadily and his lateral wound healed. He had however a persistent sinus in the medial wound leading to bone. The remainder of the medial wound healed and stayed healed. He has been evacuated in excellent general condition, but with a persistent sinus. I don't know what else we could have done with him.

Case No. 2 was injured by a bullet on 12/10/44, there was a ten-day lapse before he reached us. There was a seven-inch anterior wound and a nine-inch posterior wound with multiple foreign bodies in and around a comminuted fracture of the upper third of the femur. The anterior wound was sutured and two penicillin tubes inserted into the posterior with suture. He received intra-muscular penicillin. The anterior wound healed. The posterior wound has a small sinus to bone. There are many foreign bodies still *in situ*, and I wonder if we should not have spent more time trying to remove them before suture. His general condition is excellent.

Case No. 3 was wounded by a grenade 15/10/44 but was not picked up for two days. He came down to us rapidly and was sutured seven days after wounding. He had a ten-inch posterior lateral and a three-inch popliteal wound both of which were sutured. The popliteal wound healed but there is a persistent sinus to bone in the posterior lateral wound with occasional pocketing. Culture of the pus reveals *B. coli proteus* and diphtheroids. In view of the two-day lag before reaching an F.S.U. we might have been wiser to use penicillin tubes in the case.

Case No. 4. I have no apologies. He was wounded by a grenade 17/10/44, the fragment entering the lateral aspect of the thigh, shattering the upper third of the femur, passing on to rupture his urethra. Twenty-three hours later the wounds were debrided and a suprapubic cystotomy performed with

multiple drainage wounds. He reached us 16 days later with a nearly healed suprapubic wound. (He had pulled out his catheter some days before) and two large clean through and through wounds of the thigh. These were sutured. Five days later it was found that pus and urine were coming from a small opening at the base of the scrotum, about an inch above the medial thigh wound at the site of a previous drainage wound. A huge abscess cavity was found to extend outward behind the femur and inward to the base of penis. A drainage wound was made in the buttock and Major Benison opened the suprapubic cystotomy wound to re-insert the catheter. His general condition was extremely poor but gradually improved, drainage diminished and 20 days later he passed urine per urethra. His condition now is excellent but there is still a sinus tract leading to bone. Urine is evidently good for bone healing for his fracture has united.

So much for the four failures. There is one further case I wish to present as a late complication of a thigh wound. This man was injured by a shell, 1/9/44, and received flesh wounds of the right buttock and thigh. Eight days later all wounds were closed after removal of the foreign body. Two penicillin tubes were inserted. His wounds healed fairly well, but three weeks after admission he complained of left loin pain and various renal investigations were done showing the presence of a left hydro-nephrosis. He was at this time up and about the ward. On the 8th October, one month after wound suture, he slipped on the ward floor, heard something crack in his thigh and fell. The X-rays are as shown, at this time all wounds were healed. He was transferred to the Orthopaedic Ward and placed in skin traction.

Three days later he became pyrexial, his thigh was markedly swollen and acutely painful. Six days after his closed fracture had occurred an abscess appeared posteriorly which when opened and explored led directly to the fracture site. His condition did not improve in spite of adequate drainage, penicillin and sulphonamides, and finally amputation was performed. The pathologists have spent hours over the sections and finally report "acute inflammation." His general condition is now excellent. Did he fracture his femur through an area of osteomyelitis caused by the foreign body, although there is no evidence of fracture in the original X-rays? Is this a unique case or must we watch for similar unsuspected catastrophies?

There is just one thing I would like to emphasise in conclusion. The results shown are not the work of one individual. They have been obtained by the co-ordinated team work of all the members of the 16th Orthopaedic Centre, helped and encouraged by the Officers in charge of the Surgical Divisions to which the Centre has been attached, and by the sympathetic co-operation of the Commanding Officers. The treatment of the patient with a compound fracture of the femur must be a "combined operation."



## EARLY CLOSURE OF COMPOUND FRACTURES

by

Lt.-Col. R. W. HENDRY, RAMC

The success of the two stage method of treatment of soft tissue wounds when use is made of modern bacteriostatics is now established. As has been shown, some 80% will be healed in 12-14 days if certain principles are strictly followed. These are:— (1) early excision combined with local introduction of bacteriostatic, (2) non-interference in transit, and (3) suture in 7-10 days using penicillin in some form. Extension of the two stage procedure to the treatment of open fractures follows naturally since these are but soft tissue wounds complicated by bony damage. In this paper I shall show the results of 184 battle casualty open fractures from the Gothic Line battle (Sept.-Nov.) treated by this principle in No. 93 (Br) General Hospital. I think that I can best do this by describing the type of case, and by stating the aims and principles of the line of treatment adopted. I shall mention the technique and briefly discuss the results.

The cases were admitted to us having been evacuated by air and sea convoy. All road accidents have been excluded. No selection of cases was made. I repeat this as I think it is important—the cases were consecutive as they came from the convoys. Fractures of the femur treated in the special centre are not included. Treatment of the wound was uniform and a standard routine was followed regarding both method of application and dosage of the penicillin.

### Aids of Treatment

Our aim was to close all compound fractures as soon as possible with the aid of penicillin. These would then become simple fractures and should unite within the normal time limit of each particular bone. By taking a consecutive series we hoped to determine what percentage of cases could not be sutured either because of a skin defect or because of infection.

### Principle of Treatment

Extensive experience in the use of penicillin for the closure of soft tissue wounds convinced us that to obtain the best results it was essential to maintain a high concentration of the bacteriostatic locally throughout the entire wound for a certain period.

Major Scott Thomson, in his survey of 1,000 wounds, states that, while 20% of strains of staphylococcus aureus can fully resist the concentration of penicillin produced by parenteral therapy, many of those strains could be influenced by the increased concentration that local therapy might provide. We believed that local administration was the logical mode of attack. When a missile passes through the soft tissues and fractures a bone, the wound contains blood-clot, bone chips, devitalized tissue, foreign bodies and infecting organisms—the so called "hæmatoma." To remove this completely necessitates a "wound excision" too radical to be justifiable. One must assume therefore, that all battle casualty fractures are infected. In the early stages the infection is limited to the "hæmatoma." The need for the bacteriostatic is then local, but to com-

bat or rule out later spread of infection to the surrounding tissues, a short parenteral course is indicated.

Our method therefore was to instil sodium penicillin solution into the depths of the wound by means of tubes. The introduction of tubes to the fracture site may well be criticised as a potential source of infection itself during the period of instillation of the solution. There is also the risk that the tubes may leave sinuses after their withdrawal. Experience of their use in soft tissue wounds however, led us to discount these dangers, and this confidence has been justified.

### Technique of Treatment

Very briefly, the technique employed was to take the fractures to the theatre within 24 hours of arrival. On an average this was on the sixth day after wounding. The plaster was removed, a wound swab taken, and the wound area shaved and prepared in the usual way. A finger was then gently inserted into the wound to determine the extent of the injury, and to ensure that no loculations of exudate were present. It was seldom that any other procedure was necessary. If any foreign body was easily accessible it was removed provided that no long search was entailed. All foreign bodies at the fracture site were removed. This is a factor of great importance. The penicillin tube was then introduced through a stab incision—about half-inch from the wound edge and guided to the fracture site—one to three tubes were used depending on the size of the wound. The technique then varied depending on whether or not complete suture was possible. Where complete closure could be performed, suture was proceeded with. No sutures were used for the muscular or fascial layers. The skin alone was approximated with interrupted stitches of silk-worm gut about one-third inch apart. Much care was taken to ensure edge to edge apposition and to seal the wound. We did not hesitate to undercut freely when required, but in the early cases, we did not attempt skin-slides or skin-grafting at the time of suture. Many of the wounds closed were mildly infected. We made every effort to obtain complete closure in as many cases as possible, and this in some cases led to a fair degree of tension in the wound. This tension, provided it is not excessive, is not harmful where there is a good muscular layer between the skin and the bone. Where, as for instance in tibial fractures with wounds along the sub-cutaneous surface there is not this muscular layer, tension is inadmissible. Failure will be the result every time.

Complete closure was not always practicable. In some cases skin loss was too extensive. In these cases the wounds were partially sutured. We aimed to reduce the wound area to a minimum, and do a skin-graft or complete suture later. Finally, in a few cases of extreme skin loss or established infection, even partial suture was impossible. On completion of the suture a padded plaster case was applied leaving a small hole for each tube. The first injection of penicillin was made before leaving the theatre.

### After Treatment

Three ccs of a sodium penicillin solution (500 units per cc) were injected twice daily into each tube for five days (i.e. total 15,000 units per tube). Before injecting the solution aspiration through the tube of any collection of fluid exudate or pus was performed. Full aseptic precautions were observed. At the end of five days the tube was eased out of the plaster and the opening in the plaster covered by a dressing. Each case also received 300,000 units sodium penicillin parenterally by intramuscular injection (20,000 units every three hours). This course commenced on the day of operation.

A check X-ray of the fracture was always taken.

On the 14th day the wounds were re-examined in the theatre, and the stitches removed. If the fracture was not yet closed a wound-swab was again taken for bacteriological examination. In those cases where only partial suture had been carried out, it was sometimes possible to complete the closure either by suture or by skin-graft. A fresh plaster cast was then applied and a check X-ray again made.

No further inspection of the wound took place until the 6th week. At this time our final assessment was made because disposal had then to be decided. Cases were classified into three groups: (1) those completely healed, (2) those in which the fracture was sealed off and a granulating wound was present and (3) those in which the fracture was still open, either widely or by a small sinus.

### Assessment of Results at Sixth Week

Of the 184 fractures treated, 132 (i.e. 72 per cent) were closed at the sixth week. Of these, 110 (i.e. 60 per cent) were completely closed with sound skin healing, the remaining 22 had healthy granulating wounds. 52 cases (i.e. 28 per cent) remained as open fractures. This figure (52) requires some elucidation, as the term "open fracture" is apt to imply widely open. Eighteen cases could not be sutured at all because of either gross anatomical skin loss (5), or in 13 cases, infection, chiefly gas gangrene (9). Of the remainder, the wound had closed down to a small sinus in 28 cases. We could reasonably expect complete healing within a short period in quite a percentage of these. Eight we put as complete failures, one of which had to be amputated for clostridial infection with secondary hæmorrhage. These are the results at the sixth week. (I shall discuss later the problem of the cases where no suture is possible).

TABLE I  
Summary of Results (At Sixth Week)

	Method of Treatment	No. of cases	Closed Fractures		Open Fractures	
			Skin Healed	Granulating wound.	Small sinus.	Widely open.
106	Complete suture	114	93	5	13	3
	Partial suture	52	17	15	15	5 (one amputation)
	Suture impossible	18	—	2	3	13 (three amputations)
	Totals	184	110	22	31	21
			132		52	

### Commentary

Quite apart from any estimation of results of actual skin healing, the lack of any constitutional disturbance and the general well-being of the patients were striking. The men felt well and looked particularly well. The picture of chronic sepsis, did not develop. No case developed clostridial infection or cellulitis during treatment. No case died. As for the wound scars, fibrosis was minimal; a linear scar replaced the familiar irregular puckered area, and when immobilisation had ceased, the surrounding soft tissues were not thickened and scarred, but soft and pliable. Performance of active exercises was undoubtedly facilitated with earlier recovery of function.

Table II sets out the results of complete suture as they apply to individual bones. Of the 114 complete sutures performed 98 or 86 per cent were closed fractures in six weeks.

TABLE II  
Results of complete suture (At Sixth Week)

Bone Involved	No. of Cases	Closed Fractures		Open Fractures	
		Skin Healed	Granulating Wound	Small sinus.	Widely Open.
Humerus	39	34	—	4	1
Tibia & Fibula	26	16	3	5	2
Fibula alone	6	6	—	—	—
Radius & Ulna	24	23	1	—	—
Scapula	7	5	—	2	—
Tarsals and Metatarsals	10	7	1	2	—
Patella	1	1	—	—	—
Clavicle	1	1	—	—	—
Total	114	93	5	13	3

Considerations of the results showed that the failures occurred in situations where there was inadequate soft-tissue covering for the bones. Thus whilst the humerus, radius and/or ulna, fibula and scapula fractures show results of 90 per cent, the tibial and tarsal fractures give only 60-70 per cent.

Some of the cases of arm, forearm and scapular injury were very severe and yet the results were excellent. At the same time probably the successful tibial and tarsal injuries were of the less severe variety and occurred over the flesh covered parts of these bones, e.g. over the outer side of the leg in the case of the tibial fractures. There is a well known gutter type of fracture which occurs over the subcutaneous border of the tibia and ulna and even if skin can be made to roof over the gutter, failure will result every time. The name of 'tentage' has been given to this procedure. These fractures must be allowed to granulate up and be skin-grafted later.

Table III sets out the results of partial suture as they apply to individual bones.



TABLE III  
Results of Partial Suture (At Sixth Week)

Bone Involved	No. of Cases	Closed Fractures		Open Fractures	
		Skin Healed	Granulating Wound	Small sinus	Widely Open.
Humerus	5	3	1	1	—
Tibia & Fibula	20	5	6	6	3
Fibula alone	4	1	3	—	—
Radius & Ulna	13	5	5	3	—
Tarsals & Metatarsals	9	3	—	4	2
Scapula	1	—	—	1	—
Totals	52	17	15	15	5

### Incomplete Suture

Fifty-two cases were not suitable for complete suture. In almost all instances this was due to anatomical defect in skin. The term "Partial suture" is used when either only one of several wounds is sutured, or when only part of one wound, can be so dealt with. That two out of three (32 of 52) were closed in six weeks seems to justify the procedure. Failures again occur in the bones with poor tissue covering.

I think that these figures can be improved on by either combining partial suture with skin-grafting at the primary operation in the Base Hospital or by partial suture followed in a few days by skin-grafting. I also think that where complete suture is impossible at the first operation, the local instillation of penicillin should be augmented by a larger parenteral course than was given by us. I would suggest 500,000 units.

### Cases Unsuitable for Suture

These are the problem cases:

Eighteen cases in the series were unsuitable for suture for various reasons — 9 because of clostridial myositis or cellulitis — four because of established pyogenic infection and five because of gross tissue loss. All these cases were given the routine treatment.

Three limbs had to be amputated — two for clostridial myositis and one for sepsis. In a consecutive series of battle casualty fractures a certain percentage will be of extreme severity. These 18 cases were in this category. In several amputation was contemplated, but apart from the three cases mentioned was found to be unnecessary.

I do not propose to discuss these cases in detail. We have now considerably modified our line of treatment regarding them. The majority were infected fractures of the tibia and fibula. When such fractures are found to be unsuitable for suture, I think that the closed method of plaster treatment should be abandoned in favour of open methods on a Braun's frame or Thomas splint with skin or

skeletal traction. The wound should be treated by daily dressing or irrigation if badly infected. A course of parenteral penicillin from 500,000 — 1,000,000 units should be given along with the local treatment and at the earliest opportunity the wound should be closed by skin grafting. We have recently had very much improved results with this line of treatment.

### Conclusions

These then were the results we obtained in a serious attempt to apply the two stage procedure of closure to open fractures.

Latterly in cases where complete closure was possible we have omitted the parenteral course and used the local treatment only. Although we have not done enough cases to form a control series, the results seem just as good.

From our experience I would say:—

- (1) Where complete suture is possible, use only local penicillin.
- (2) Where the wound can only be partially sutured, combine a parenteral course with the local treatment, and within 5 — 10 days either complete the suture if possible or cover the remaining part of the wound with a skin-graft.
- (3) In the group of severe cases where no suture is possible (and most of these cases will be infected fractures of the tibia and fibula) treat the limb by open methods, give a massive course of penicillin parenterally (a 10-day course) and then skingraft early.

### Brigadier Edwards

Many points have been raised since we started this morning, and this seems to be the right time for a general discussion.

### DISCUSSION

#### Col. Hampton, M.C.

It has been a great pleasure and a privilege for me to discuss this subject with Major Furlong and to have seen the splendid results obtained in the treatment of fractures. I would like to bring up a point which may be worthy of elaboration. Is not the result we have obtained in all of these femoral injuries dependent not upon the major operation but upon the initial surgery which has been done? We feel this is so. We feel that the most important thing we can do at the base on femurs is to make sure that the excisional surgery is complete. We make absolutely certain that all foreign material and bone fragments are removed. I think there is some difference of opinion between our surgeons and the British surgeons on the latter point. We make a point of seeing that these fragments are removed in the forward areas before going to the base. We have not been carrying out a complete suture. I cannot say if our jobs are any better than the excellent ones presented here.

#### Lt.-Col. Watson, Adviser in Orthopaedics, AFHQ.

I agree with Col. Hampton. It would appear on theoretical grounds at any rate, that it is an exceedingly difficult thing and would be dangerous to close completely the majority of compound fractures. It is almost impossible to excise a compound fracture, as there is extensive damage to deep tissues. There



are, in most of them, fragments of bone, which may be likely to provide a place where bacteria can grow. But, I think the papers we have heard this morning show that given certain conditions it is in fact possible to close them without any untoward results, or, except in a small proportion, with infection occurring. It seems to me that the things which are essential are, that the forward surgeon be able to excise the wound, that the muscles are decompressed, a standard method of splinting is employed to keep the parts completely at rest and that the wound should be left completely undisturbed until it is in the operating theatre at the base hospital. With regard to penicillin, I am sure successful results must be partially attributable to the proper use of penicillin. We have heard of the two methods employed, the parenteral and local injection through tubes. It would seem from the papers we have listened to this morning that in bones completely surrounded by muscle, there is an adequate blood supply, and a parenteral course will provide sufficient concentration at the fracture site to reduce or abolish infections. Another factor is, as Major Stimson pointed out, the patient's general condition before and after the debriding of the wound. Regarding the time interval, I think most of the surgeons who spoke this morning agree that delayed primary sutures of fractures should be done certainly somewhere before the tenth day. Most of them are done about the seventh. That of course implies that cases must be evacuated back in reasonable time. We have had a little experience recently of evacuation difficulties. Delayed primary suture has been done at one place and then the patient is evacuated back for treatment. That, I think, has proved to be on the whole, unsuccessful, as it adds another ten days to the time before definitive treatment is commenced. Therefore it is important that the hospitals or orthopaedic centres should be as near as possible to the forward units to treat the fracture and enable the evacuation to be made within a reasonable time. Major Burge referred to the question of X-ray in forward units. This is a matter of some importance in regard to compound fractures. Col. Hendry I think, emphasised the importance of taking out foreign bodies. I am sure that is best done at the first operation, when the wound is debrided initially. I think this applies chiefly to deep metallic fragments close to, or within, the actual fracture site. I don't think it means that surgeons should try to remove very small pieces. I do think it is important to X-ray before the primary operation. With regard to removal of bone fragments — I differ from Col. Hampton in that where the bone fragment is detached but is not very large, or where there are several fragments, and their removal would leave a gap, I think most British surgeons would advise they should be left in to form a graft. It is a fact that if you can get successful early closure their presence does not seem to matter. Col. Hendry says that closed plaster treatment of a wound which it is not possible to suture is bad, though I am not sure I can agree with that.

I certainly would like to congratulate the two speakers on femurs. Of fracture femurs very few have actually gone back to duty in this theatre, and it is a fact that the majority will return to U.K., but they will go back healed. When the fracture is consolidated it is quite possible a big proportion of them will be retained in the Forces, and so effect a contribution to the man-power situation.

*Brigadier F. A. R. Stammers, Consulting Surgeon, Forward Areas.*

It has been rightly pointed out that delayed primary suture was practised during the last war. With generous supplies of penicillin, with appropriate organisation at the Base, and with the general enthusiasm there is to put this two-stage treatment into action the results should be enormously better than in 1914-18. I remember that at a meeting of divisional officers just before Cassino it was asked of forward surgeons that they indicate on the Field Medical Card "suitable for delayed suture". Experience since then has taught us that very few wounds are unsuitable for this treatment, and it becomes more rational, in order to cover the far smaller proportion, to say "unsuitable for delayed suture". Major Burge gave a most interesting description of the treatment of soft tissue wounds, but I would like to question the advisability of his method of keeping a wound open for a few days by stitching the skin edges outwards over small rolls of gauze. I wonder whether this would not cause oedema, just as the former fashion of turning back amputation flaps and bandaging them in that position was found to cause oedema of the flaps.

It is interesting to compare the figures of Cassino days and those of the Gothic Line battle. The results of delayed primary suture during the latter battle were less good than during Cassino days, and this because the lines of evacuation in September and October were very long, and in consequence the optimum time for the delayed suture was missed. As pressure of work eased off we were able to establish delayed suture centres in Army areas, and were therefore able to apply delayed suture at the optimum time. The surgeons who did this work in these more forward centres have produced results comparable with those of the Cassino battle. At this time of year evacuation by air on the east coast is most unreliable, but once activity starts again these cases will once again have to be sent to more distant hospitals. Not being an orthopaedic surgeon I cannot give personal experiences of conserving loose fragments of bone; but with the general use of early wound closure, aided by penicillin, I am prepared to believe that not only the question of saving detached fragments of bone but also the earlier suture of nerves and of tendons will, under carefully controlled trials, be attempted with a good chance of success.

*Colonel E. D. Churchill, MTOUSA*

As spokesman for the surgeons of the United States Army Medical Corps, in this theatre, I wish to express our deepest thanks for being included as guests in this meeting.

We have in the United States a publication known as the Congressional Record. In addition to the formal speeches of our congressmen and senators, privilege is granted for the incorporation in the Congressional Record of a large number of miscellaneous items, many of which are not suitable for debate on the floor of Congress. At least some of these have the purpose of framing the remarks of congressmen so that their place in history is preserved for students of the future. Possibly this is the origin of the expression "keeping the record straight". I offer two items, neither of which is debatable, for incorporation in the records of this congress so that the students of wound healing 50 years from now will know that we had some idea



of our place in surgical history. The first of these appeared in 1918 in Paris in a publication of the Red Cross known as "War Medicine" and was written by Rene Block:—"The best moment for delayed primary suture is the fourth day after operation; this is the time at which, in the service of Dr. Lemaître, we do the first dressing of wounds which have not been sutured, provided the patient is without pain or fever and the bandage has not become soiled at an earlier date. If the wound is not sufficiently clean, it is best to delay suture for several days more; it may be practised as late as the 12th day.

"The operative technique is identical to that for immediate primary suture; rather than suturing the whole *en masse* with silkworm gut, it is better to suture layer by layer with fine catgut in order to re-establish the anatomical layers, and especially to make possible the natural gliding of the tissues.

"For those who know how to effect a good ablation and who have the technique of delayed primary suture well in hand, the possibilities of this procedure are infinite. Thus between the fourth and the twelfth day we have been able to close wounds with extensive gas gangrene, even when accompanied by fracture, in which cases the best of results have been obtained."

The second item goes back a bit further, in fact, to Lord Lister. It is of interest that this particular quotation was carried forward into the British Medical History of the War of 1914-1918 as if surgeons at that time were a bit confused by hypochlorinated solutions, Bipp paste and iodine, and were seeking to clarify their place in history. "If, for example," Lord Lister is quoted, "a pair of forceps is handed to the operator with the intervals between the teeth occupied by dry septic pus and a portion of this dirt becomes detached and left in the wound, the evil cannot be corrected by any antiseptic wash that is now at our disposal or that the world is ever likely to see."

Colonel T. D. M. Stout, NZMC

I have been one of the lucky men who recently visited the old country, and I find the old country is a place where if one has eyes and ears one can learn more than in any other place in the world. I must first of all compliment the speakers of this morning. I think they are excellent, and I agree with every word they have said. The papers from forward areas are particularly good. Forward surgery now is about as excellent as it can be. There are several points I would like to make. The first is in regard to the primary treatment of wounds. I agree with Major Burge entirely. If the foreign body is at all accessible, it should come out.

On the question of bone, I cross swords with Colonel Hampton. One of the points I tried to find out about in England was whether bone which had become completely detached should be left alone. I was told, and I want to emphasise this, "it must be left in". If an exposed bone, it has got to be covered at the first opportunity, for it dies on the surface, and once that happens, nothing can grow over it. Exposed bone has got to be covered even if you have to make a big wound at the side of it.

As to penicillin, when is it to be given? I must ask whether in all severe cases the penicillin is given through the L of C. If penicillin is to have full effect,

it must be given on the way. Penicillin will then have a better chance; I think it should be given that way.

Major J. B. Bickerton, RAMC

During the Gothic Line battle, No. 4 Orthopædic Centre had the opportunity of treating 108 cases of fractured femur with delayed primary suture and penicillin. We closed completely 62; 38 were partially sutured, and the other eight were not closed at all. Our results were:—Of those totally sutured, 80% were closed fractures in four weeks, 90% in eight weeks; of those partially sutured only, 52% were closed fractures in four weeks, 74% in eight weeks and 90% in 12 weeks.

Lt.-Col. A. Soltysik, Polish Medical Corps.

I will take into consideration some details of dressing and splinting. Common features in all Tobruk Plasters I have ever seen, were: the excised wounds, dusted with sulphonamide powder or calcium-penicillin, packed with vaseline gauze and covered with many layers of gauze and cotton.

In such dressing, the wounded, especially those with compound, comminuted fractures and lacerated soft tissue wounds, after some days, would feel every day increasing pain. The pulse rate and temperature were higher, the smell very offensive and the general condition, especially after transport, was miserable. Immediate change of dressing was necessary.

In contaminations as well as other factors, access of the air is important, but it is too often neglected.

Undoubtedly, the fear of circulatory disturbances, possibly caused by the plaster being too tight, or tightening owing to muscles swelling, justify the application of the Tobruk Plaster with thick padding, but on the other hand it was shown long enough ago, that wounds should not be plugged with tampons, and such a dressing plugs as tightly as a cork. The loose packing, draining the cavity of the wound is no aid, if the surface is completely closed from approach of the air and thus does not allow pus-discharge. We must try to secure contact with the air, reduction of formation of pus and facilitation of discharge.

Keeping in mind the value of padding for plasters, especially in cases to be transported, we should not entirely dispense with it. We can employ a layer more or less half an inch thick, *except for the wounds*. These after "toilet" should be dusted, then covered with a single layer of vaseline gauze only, and then immediately covered with plaster. In the absence of sterile vaseline gauze I prefer to cover the wound directly with plaster, rather than to cover it first with some layers of ribbon gauze.

In this way, the wounds have contact with the air which diminishes the pus discharge; the plaster closely fit to the wounds sucks up, simultaneously drying it up and retaining this capacity for a long time. In placing the rubber tubing, before the usual plaster application, we try to avoid the wound surfaces and therefore the rubber is often placed serpentine and not straight down.

The extension made by adhesive strapping applied to the leg is certainly appropriate, but not for the period of evacuation or transport. The need of careful vigilance can only be satisfied in stationary treatment. Many femur fractures observed in our



division showed the inadequacy of strapping extensions applied in the Field Ambulance. Pressure sores were very frequently noted, in spite of correct appliance of soft encircling bandage. In other cases the bands were not surely enough secured. In almost all cases the foot was too loosely supported.

It appears to be better to limit the plaster extension to the fractures in the upper third, which without the adhesive strapping cannot be fixed in Tobruk Plaster only. The remaining time, in the other cases involving the middle and lower 1/3 femur, may be used to improve the application of the Tobruk Plaster and so support the limb better.

The dressing made in that way is airy, absorbent and dried up, and we may expect that after some time, by change of dressing, the wounds will be clean and ready for delayed suture or secondary treatment.

There are many agents, which cooperate, before, during and after the treatment of wounds, but skilfully performed surgery is the most important.

If we want to do it in the best way, we must have the means, and an adequate table, and the operating table in Field Ambulance, and even in some hospitals is inadequate.

"The field orthopaedic table," as I call it, consists of two main parts:—

- (1) a high table to support the head and the chest of the patient only.
- (2) two adapted Bohler apparatus, fixed on two lower mobile benches.

The small saddle, attached to the appropriate part of the Bohler apparatus should be covered with rubber tubing and is on the same level as the higher table. A system of mobile pulleys together with typical Bohler extension system for the calf, enables the traction on lower extremities in the desired position.

I consider, the closed P.O.P. dressing essential in the first period of treatment, for transport, and after every operation on the limbs. The time lapse between the operation and first change of dressing depends in my opinion on the patient's general condition and the amount of discharge. If there is abundant discharge with offensive smell, or complaints of burning pain, I cut windows in the plaster over the wound and apply gauze soaked in silver nitrate solution (1/4%). Using this method, improvement has been observed, not only in the patient's subjective feeling, but also in his general condition. This treatment is not very popular and was never duly appreciated. In 20 years of surgical experience I have had the opportunity to check the value of this method in the treatment of infected wounds.

In the treatment of femur fractures the problem of the evacuation of the casualties roused my particular attention. The general hospitals in the vicinity of the front line are not and cannot be the last link in the treatment. There are many reasons why patients should be evacuated to the rear, to home-hospitals, which are much better equipped.

When we take under consideration, that in all war theatres there are hundreds and thousands of wounded of this kind immobilised for long periods

in their beds, then I think that to enable their evacuation home from the most remote battle-fronts, even by ship, and without interruption of the extension treatment, would certainly be a step forward.

The Tobruk splint is indispensable in cases of compound and simple fractures of the lower part of the femur, but on the other hand it is not suitable for long lasting transport. The principle of getting counterpressure for the traction by means of a ring, holding the groin and resting mainly upon the tuber ischii and the inguinal region does not permit the application of an extension, strong enough to withstand successfully the muscular pull and the tendency of the fragments to slip and dislocate.

In some cases after reduction and wedging of the bone fragments, and particularly when the Kirschner wire used for traction is moulded into the plaster, a hip, spica may be of some use. However, every experienced surgeon knows very well, that even in these cases a dislocation is always possible and renewed reduction is again necessary; so even this method is not satisfactory for long lasting transport.

Looking for a solution of this problem I began to apply "the combined P.O.P. extension dressing," trying to comply with required conditions. My object was to work out a dressing, which could give the highest guarantee of maintenance of the required position, and which at the same time would offer the patient the greatest possible comfort. I modified the usual hip spica as follows:—

I transfer the counterpressure to the hip of the side affected and to the ribs, reckoning, that a sufficiently rich padding would protect the ribs from painful pressure, while the accurate moulding of the hypochondriac depressions would hold the dressing in its proper place. In spite of the traction exerted, both glutei and the sacrum remain free, not enclosed in the plaster cast, which holds only the lumbar region, which is not exposed to pressure, due to its physiological lordosis. Therefore the plaster can be accurately moulded and does not produce pressure symptoms, in spite of its tightness. All nursing problems are greatly facilitated.

Taking into account that the plaster is liable to crack, by repeated and not always expert handling during transport, I reinforce the dressing in its weakest spots, that is, in the region of the hip, groin and knee with accessory cross-wires moulded into the plaster. In this way I obtain a very strong dressing, steady enough to withstand any rough handling. Instead of traction with a weight. I am using a traction with a piece of rubber tubing fixed between the bow and the splint end.

Developing further the conception of a dressing permitting transportation I made a very simple and light, portable extension apparatus, which offers the possibility of treatment and in emergency also of transport.

This apparatus which I have called the "S.5" allows for continuous traction applied either by weight extension or by means of rubber tubing (or possible steel springs) in every case of femur fracture.

(The splint "S.5" and the photographs are at the exhibition of the Conference.)



## THE CLOSURE OF AMPUTATION STUMPS

by

Lt.-Col. J. A. MACDOUGALL, RAMC

The closure of amputation stumps is a most important subject. A man subjected to an amputation has undergone grave physical and psychological trauma. His early return to normal surroundings by the most comfortable route is essential. If this be delayed or awkwardly accomplished a permanent invalid may be the result. The observations which comprise the subject matter of this paper are the result of the experience gained in the four months ending December, 1944. They are a direct result of an attempt to minimize secondary closure and re-amputation in the presence of sepsis.

Early in this period we were privileged to perform both the amputation and the delayed closure. Later, we have performed the second half of the two-stage operation.

The series is composed of 43 amputations in 41 patients. These amputations were sited as follows:—

Below knee	21
Above knee	15
Below elbow	1
Above elbow	6

It was possible to treat 31 of the 43 amputations by delayed primary suture. The technique employed embraces nothing new. The original dressing was removed in the theatre. Any ligature material was then removed except that on the main blood vessels. It was interesting to note that in the case of the main vessels retraction had caused the ligatures to disappear deep to the surface. In but very few cases was a further section of bone or muscle necessary. The surfaces were dusted with penicillin-sulphathiazole powder. The flaps were fashioned and closed over a through and through rubber tube drain, and the stump was then dressed with a padded plaster cap. The drains were removed on the second day and the sutures on the seventh or eighth day. Dressing of the wound on the seventh or eighth day is indicated because the drainage of serum subsequent to removal of the drain, renders the dressing moist by this time. Sutures are removed at this stage only because of convenience. In my experience it is considered that keeping the suture line dry is a most important factor in the success of a delayed suture.

The results were most encouraging.

27 were healed 90 to 100%

3 were healed 70 to 90%

One case failed and had to be subsequently resutured because of hæmorrhage beneath the flaps. This was recognized when the drain was removed, and after evacuation of the clot, suture was performed with success.

Secondary suture was performed in eight cases, four of which required slight shortening of the stump. The constant factor in all eight cases was infection by gram negative organisms. The fact that gram positive organisms were found in but three cases must have been due to previous chemo-therapy.

Secondary closure was performed with gram negative infection still present, the usual tube drain being supplemented by rubber glove drains under

the mobilized flaps. It was surprising to see healing progress in the presence of gram negative pus if the gram positive organisms were held in abeyance.

90 to 100%	4
70 to 90%	3
Failed	1

The four remaining cases required re-amputation at a higher level.

Closer study of these cases reveals two sets of factors, those assisting and those impeding delayed suture. It is perhaps best to discuss the factors assisting by describing an ideal case. This amputation would be performed above the site of compound fracture. The section would be through healthy tissue, cutting the muscle and bone in the same plane. This obviates any cavity to fill with exudate and become infected. Adequate flaps should be planned, but need not be completely fashioned. Ideally after dusting with penicillin sulphathiazole powder the flaps are laid loosely over the stump section, separated only by a layer of vaseline or plain gauze. The dressing of choice is a padded plaster which should be firm but not tight. It is more than likely that the flaps have been subject to trauma at the time of the original injury. Therefore they require the protection and splinting of plaster. However, the flaps must not be subjected to pressure or they may slough. In the case of below knee amputations the plaster should extend to the upper third of the thigh. Amputations in the lower third of the thigh are protected by a plaster extending to the perineum. One-legged plaster pants offer the best dressing for amputations of the mid and upper third of the thigh. The plaster pant also affords the only means of preventing flexion at the hip in short thigh stumps.

The factors which impede or prevent delayed suture in my experience are four in number.

1. It has been advocated that flaps be held with stay sutures pending delayed suture. This has been found not only to be unnecessary but harmful. All such cases have been found to harbour a blood clot under the flaps. The inclusion of a drain or pack has not served to prevent this hæmatoma. The fact that sutures do not travel remains inviolate.

2. The second detrimental manoeuvre is turning back skin flaps in an attempt to promote drainage. When the flap is repositioned two phenomena are observed. At the base of the flap where it is folded a definite resistance of rubber-like quality is experienced. Reposition is also accompanied by blanching of the flaps. It has been observed that normal circulation does not return before the suture is completed. This interference with the circulation was probably the cause of two of the incomplete successes in the delayed suture series.

3. The third impeding factor is the failure to apply a plaster dressing. In only two cases were we able to perform delayed suture where plaster was omitted. The patient travels in pain, the dressings become saturated and slip. Any or all of these factors cause the dressing to be removed before



arrival at the unit where delayed suture will be performed, the result being that the stump arrives in an oedematous condition if not already infected.

4. Disarticulation offers an almost insurmountable barrier to delayed suture. All three cases arriving at our hospital required amputation, higher up, in order to close the stump. It is of course realised that disarticulation is often a life-saving operation. However, the poor circulation and difficulty in mobilizing the skin in the region of joints, particu-

larly the knee and ankles, make all delayed closures of disarticulations difficult and hazardous.

Chemo-therapy and treatment by plasma and blood transfusion are considered outside the scope of this paper and have been purposely omitted.

In closing I would like to thank the forward surgeons. The excellence of their work has made the performance of the second stage operation a pleasure.

## LATE CLOSURE OF WOUNDS

by

Major PATRICK CLARKSON, RAMC

No. 4 Maxillo-Facial Surgical Unit

This paper describes methods by which wounds have been closed late by short-term operations. It is based on 181 wounds from the Tunisian, Sicilian and Italian campaigns. These cases were operated on after the second week and before the 34th week.

The wounds described here belong to one of two groups.

### 1. Big Wounds. 130 cases.

These are wounds of a long or indefinite period of natural healing.

### 2. Chronic Wounds. 51 cases.

A chronic wound is defined as a wound still unhealed at eight weeks, or one unhealed a month after a definitive attempt at closure. Forty chronic wounds were treated in Algiers. The marked decline in the chronic wounds referred to us in Italy (10 out of 103 as compared with 41 out of 78) in spite of the greatly increased scale of fighting, is attributed to the success of the policy of early closure, and to the fact that covers by free grafts and simple flaps are now rightly considered as the province of the general surgeon and are done early rather than after a period of delay in plaster.

TABLE I

<i>Total number of late wound closures 2-33 weeks old</i>					
-	-	-	-	-	181
<i>Big wounds</i>					
-	-	-	-	-	130
<i>Massive wounds (500 sq. cms. and over; or 200 sq. cms. with an amputation)</i>					
-	-	-	-	-	26
<i>Large wounds 70-200 sq. cms.</i>					
-	-	-	-	-	43
<i>Wounds of 40-70 sq. cms.</i>					
-	-	-	-	-	61
<i>Chronic Wounds (these were 30-100 sq. cms.)</i>					
-	-	-	-	-	51

Algiers chronic wounds 41 out of 78

Naples chronic wounds 10 out of 103.

All except a small minority of the operations described have been short term, in that they have not involved tube pedicle repairs. Belly-to-arm and cross-leg flaps for the repair of arm and lower leg defects unsuitable for closure by local flaps or free grafts have been used for a small minority.

### METHODS OF LATE CLOSURE OF WOUNDS

TABLE II

Approximation and Secondary Suture	52 cases
Local flaps (Swinging or Rotation)	32 cases
Free grafts	81 cases
Patch graft closures	62
Sheet graft closures	19
Combined operations. (Local flaps combined with sheet grafts)	21 cases
Cross-leg and Belly-to-arm flaps	8 cases

### Closures by Approximation and Secondary Suture. 52 cases

Twenty of these 52 cases were between 70 and 300 sq. cms. in all.

The value of this method in closing oval and rectangular wounds as well as linear wounds is not perhaps widely enough appreciated. The closure of oval defects depends on wide undermining and in opposing the points of the wound which most readily lie together rather than directly opposite points.

Secondary suture after radical excision provides linear closure of the wound by a flap of skin and fat with a supple scar which will stand up to pressure.

The best results in the early sound healing is seen when a wound is closed in the one line.

### Closures by Local Flaps (Rotation or Swinging) 32 cases

In these 32 wounds the secondary defect was closed by approximation.

At this operation a flap of skin and fat is transferred on a hinge from a neighbouring site where it is present in excess, to cover the defect.

The secondary defect can often be closed by approximation; but if this approximation produces any tension on the flap a free graft must be used. A free graft gives a better functional result and is more certain of 100 per cent take on a secondary than on most primary defects.

Rotation flaps have been of particular value in groin and upper thigh wounds where viable flaps can generally be planned to close easily defects of up to 100 sq. cms. In this series swinging flaps have commonly been of  $10 \times 9$  cms., and the rotation flaps of  $9 \times 9 \times 2-3$  cms.

**Closures by Free Grafts. 81 cases.** (Sheet graft closures 19. Patch graft closures 62.)

#### SHEET GRAFTS:

An altogether higher standard of technique and preparation is needed in sheet covers of granulating surfaces than when patch grafts are used. An 80% take of a sheet is the standard generally expected for an adequate result; yet the difference between 80 and 100% is healing with full function in a week and healing delayed for two - six weeks with the final result impaired by some degree of scarring.

Granulating wounds of more than two weeks old which have been covered by a sheet graft have had a preliminary radical debridement; if more than eight weeks old they have been radically excised. In the arm and leg these preparatory operations have been done under tourniquets. The patient has started a full course of penicillin and three - six days later the sheet has been applied.

Wounds closed by sheets have been:

1. Wounds of not more than 200 sq. cms. Wounds needing more than one dermatome drum (200 sq. cms.) are generally best closed by patches rather than sheets.
2. Wounds of popliteal and cubital fossæ where a repair of good quality skin is needed.
3. Wounds free from hæmolytic streptococci; and wounds which have had, or have been made to have, by preliminary excision, a reasonably even contour with little pus production.

A sheet graft is better fixed by glue than by pressure. Sano extracts or gum acacia (technique of Capt. Rubin, U.S. Army) have been used. This swing from pressure towards glue as a means of fixation has been one of the main changes of technique in recent years, and represents an undoubted improvement in technique.

#### PATCH GRAFTS:

The great advantage of patch grafts is that they are simple, safe and certain; they can be made to stick and grow on infected surfaces anywhere on the body. Nevertheless, a good result with a sheet is always a better result than a good result with patch grafts. The scar is more supple, and durable, and lacks the draught board appearance of patches which in exposed sites is a concern to the patient.

Patches have been used:

1. In very extensive areas which could not be covered by sheets. Most areas of more than 200 sq. cms. should be covered by patches rather than multiple dermatome sheet grafts.
2. Whenever a certain quick primary resurfacing was needed. This applied to certain ill patients; and to cases who had had partial loss of a sheet or a partial breakdown of a flap. Patch grafts

ensured that they were healed within a month of the first operation.

3. Wounds with much surrounding skin damage and infection. Examples of this were mine wounds in which it is difficult to get a satisfactory edge for attachment and surface for application of a sheet.

An *H. streptococcus* can occasionally float off a complete application of patches, so can a true K.L.B.; two to three applications of local penicillin are the answer to the first, and 40,000 A.D.S. the answer to the second bacteriological finding.

No other organisms seem to affect the take of patches. A finding of *staph. aureus*, *B. proteus*, diphtheroids and/or *Ps. pyocyaneus* need not delay a patch graft. However, a late progressive loss occasionally occurs in both patches and thin sheets. So far it has not been possible to blame any one organism; mycotic infection is a possibility. When this occurs a period of intensive dressings with a precise technique is necessary before a fresh graft.

**Closures by Combined Operations. 21 cases.**

Areas of 70 - 300 sq. cms. (one of 1,000 sq. cms.).

In some large defects the best functional result is only obtained by a combination of both methods, approximation, flap and free graft. It is then often possible to provide skin and fat for the part of the wound which needs it. The rest is closed by free graft. In the closure of any large defect it is always worth while considering whether some part needs a fat and skin cover which can be provided by local tissue, before choosing a cover by free graft for the whole wound.

**Closures by Cross-leg and Belly-to-arm Flaps. 8 cases.**

These cases were heel and shin defects, and forearm and hand wounds.

The scope of these methods has been limited in this theatre. Many cases who might eventually need a belly-to-arm or cross-leg flap have been given primary cover by patch grafts and evacuated to the U.K. for time and use to show the need or otherwise of more long-term surgery.

This has been particularly so of hand wounds. Almost all these cases on admission have been in need of sequestrectomies and excision of necrotic tags of tendon and fascia. The hand is œdematous and the remaining intact digits have already started to stiffen. A belly-to-arm flap as a primary repair of these defects necessitates a further month's immobilisation or at best modified movement. On the other hand a primary cover by patch grafts enables vigorous active movements to be restarted four days after operation (generally within a week of admission). These primary covers limit scar tissue, as well as allowing early movement. They can be excised at a later definitive operation when a belly-to-hand flap can be more accurately planned to meet the need of the particular patient.

#### Wound Antiseptics

Local sulphonamides have not been used. Ca. penicillin is inserted into the wound at operation. All major wounds are given a full course of parenteral penicillin which starts the day before operation and continues for a week.



## TREATMENT OF MASSIVE WOUNDS

Wounds of a surface of 500 sq. cms. and more, or 200 sq. cms. with an amputation have totalled 26.

They have included five traumatic amputations of the hip in which the raw area was of the order of 1000 sq. cms. These cases have been covered by patches in two - three doses. They have been too ill to stand a complete cover at first operation. Improvement in general condition, sleep and appetite, after a partial cover has generally been marked and rapid. Final healing has taken four - six weeks in these hip amputations. The two cases who had had a colostomy at primary operation were fittest on arrival and healed quickest after grafting. In the other three cases faecal soiling of the perineal and buttock portions of the raw stump was impossible to avoid and was detrimental.

This group of massive wounds includes two with complete avulsion of the thigh adductors. These were healed and walking without noticeable disability four - six weeks after grafting and eight - ten weeks after being wounded.

For all these massive wounds patch graft have been used, and have been combined with sheets for those wounds which had areas likely to be subject to pressure and therefore in need of good quality skin.

### DEATHS:

The two deaths were both massive wounds and both involved femur and hip joint. One was a hip amputation following a G.S.W. of the neck of the femur. He was admitted with a faecal fistula, osteomyelitis of sacrum and septicæmia and died on the 80th day. His raw area of 1000 sq. cms. had by then been partly covered posteriorly by patch grafts and anteriorly by flaps. He did not have a colostomy.

The second death was a massive gutter wound of the outer side of the hip of  $30 \times 12$  cms. and involving the neck of the femur. He died in coma and jaundice on the 72nd day. His fracture site showed normal callus and his wound was substantially healed by patch grafts. The post mortem appearances of his liver resembled those of sub-acute liver atrophy.

## PATHOLOGY

The pathological factors discussed here are those which retard the natural process of repair, or which may prejudice the success of closure by operation.

### Marginal Ingrowth and Central Fibrosis

The normal rate of marginal ingrowth of epithelium over a wound varies widely in different parts of the body. It is most rapid in the head and neck, where it may be 1 mm a day, and is more rapid in the upper limb than the lower, and in the upper parts of the leg than in the calf and foot. The marginal ingrowth was measured in the wounds reported here. Regardless of site, rates of more than 1 mm. a week were not observed; and in wounds of more than eight weeks old a total of more than 6 - 8 mms. of new skin edge was seldom seen.

The cause of this arrest of ingrowth at 6 - 8 mms. is ascribed to the progressive fibrosis and avascularity of the granulations in the central part of the wound.

In excising wounds of up to four weeks old, it is seldom possible to define a plane of demarcation between the base of the wound and normal tissue; but by the eighth week the white fibrous base of the wound is easily distinguishable from the surrounding muscles, into which it ramifies along the tract of the missile. On section after this date, the edges supporting the 6 - 8 mm. of marginal ingrowth may show vessels, but more centrally vessels are absent and only fibrous tissue infiltrated with inflammatory cells is seen. These central granulations are often as unresponsive to a free graft as they are to the ingrowing skin edge, and epithelium which survives on them is poorly nourished and commonly unstable.

The contraction of this fibrosis plays an important part in determining the size of the final scar. At the completion of natural healing the area of new epithelium may be only 30 - 70% of the area of the wound when a fortnight old. Centripetal pull of the central fibrosis on the surrounding skin has provided the rest of the cover. The deeper the wound the greater is the proportion of the skin cover provided by pull on the surrounding intact skin.

### Bacterial Infection

In this series of 181 wounds the incidence of complications—localised cellulitis and stitch abscess—in wounds not treated with penicillin, has been notably higher in the cases with preoperative h. strept. infection than in wounds infected with other organisms. The healing in cases treated by penicillin has been uniformly quieter than those closed without penicillin; but the scope of late wound closures, except for the preparation of surfaces for grafts, has not been materially increased by penicillin; the essential preparatory step remains the radical preliminary excision.

Hæmolytic Streptococcal Infection: Incidence of this infection has varied and one of the most remarkable points of contrast between Italy and North Africa has been the way in which for days and occasionally weeks on end in both burns and wound wards there has been no case with h. strept. present. There seems little doubt that this is due to the routine use of local and parenteral penicillin.

Staphylococcus Aureus Infection: This infection has been common and has persisted in spite of penicillin. It has been more common in cases showing edge redness and stitch abscess than have other organisms.

Diphtheroid and K.L.B. Infection: In countries where diphtheria is endemic the infection of wounds with K.L.B. might be expected. It has been seen in two cases. Each showed a peripheral neuritis complicating a chronic superficial limb wound of no specific appearance.

There has occasionally been some local evidence of toxicity in the diphtheroid infections; four cases of free grafts to burnt areas showed a progressive breakdown of the grafts between 10th and 30th days. During this time diphtheroids only were grown. Fresh grafts after 40000 A.D.S. took and were stable.

## COMPLICATIONS

The complications of late wound closures are vascular or infective.

### VASCULAR:

Ischæmia of flap edges for 1 - 5 cms. depth occurred in seven cases. This ischæmia was due in

five cases to tension on the flap by attempts to approximate the secondary defect. In the other two cases too large and non-viable rotation flaps were cut. These cases were treated by excision of the sloughs between 10th and 14th days and application of patch grafts.

Major hæmatomata (2 - 6 ozs.) were seen in five cases, all trunk wounds; in one the wound broke down and had to be resutured.

#### INFECTIVE:

There have been no major infective complications—major abscess or systemic infection—following these closures. Edge redness and minor stitch abscess have been common but have been markedly decreased since the use of penicillin.

#### RESULTS

TABLE III

Late Closures	-	-	-	-	-	181
Soundly healed in 4 weeks	-	-	-	-	-	170
80% soundly healed in 2 - 3 weeks.						
Of these 170 cases 15 needed additional free skin at 10 - 15 days.						
Soundly healed in 8 weeks	-	-	-	-	-	6
After free grafts (patch grafts).						
Evacuated unhealed	-	-	-	-	-	3
Died	-	-	-	-	-	2
1 Traumatic hip amputation with faecal fistula and septicæmia. Died 80th day.						
1 Massive wound hip died with jaundice and coma 72nd day.						

## THE TREATMENT OF G.S.W.s BY SECONDARY EXCISION AND SUTURE

by

Lt.-Col. THOMAS MOORE, RAMC

I speak as one who has not had the experience of the early closure of war wounds with the help of penicillin; as one whose surgical principles are still unclouded by chemio-therapeutic beliefs and who still practises surgery as a biologist rather than as a chemist. In the North African campaign no penicillin was available for the treatment of wounds and the idea of their surgical closure was put into practice only by the enlightened. It is perhaps fitting therefore, in this atmosphere of bacteriostatic magic, that I should tell you my results in the attack on soft tissue wounds by surgery alone. In that campaign chronic wounds were very common and it was really exasperating to observe the time that even small superficial wounds took to heal and the loss of duty they caused. It was a not uncommon experience to see them still unhealed in six months after the original injury. When one enquires into the reasons for the prolonged healing of wounds it is found that the following factors are involved.

(1) The large size of wound due firstly to the loss of tissue caused by the original injury, and, secondly, to the loss caused by the primary surgical treatment, although this has rightly tended to become less and less.

(2) Increase in the size of the wound, due to the elasticity of the tissue, particularly noticeable when the deep fascia has been divided.

(3) The site of the wound. Wounds of the back, particularly those over the spine of the scapula, wounds over the subcutaneous surface of the tibia, wounds over the lateral surface of the leg near the head of the fibula, all heal slowly probably due to a relatively poor blood supply to these parts.

(4) Infection. This chronic infection was never, or very seldom, dangerous to life but was undoubtedly the main factor in preventing wounds from healing. All the common organisms were found. By their constant injury to the tissues they led to

fibrosis round and deep to the wound and because of this there was always a relative ischæmia of the part so that wound healing did not occur quickly and the final scar was frequently unstable and liable to break down with the resumption of full duty. Undoubtedly the main cause of this infection is the curious medical officer or nursing officer who likes to look and see how the wound is getting on. Even under the best conditions it is difficult to dress a wound and be sure of not contaminating it, but when an all touch dripping finger technique is used contamination is certain.

It became a routine to excise such wounds radically, when they looked clinically clean, and suture them completely. Although for interest such wounds were frequently examined bacteriologically it was on the clinical appearance that the decision to excise them was made. After the wound had been carefully carbolicised it was very radically excised. The skin incision was always made a considerable distance from the edge of the wound, never less than  $\frac{1}{2}$  inch, the aim being to cut through normal skin well away from the fibrous reaction. The wound and the surrounding tissues were removed in one block, the incision through the tissues being everywhere well below the base of the wound and through healthy tissue—no matter how deep this might have to be. Occasionally anatomical considerations made this impossible, but such cases were always noted preoperatively and the excision was only curtailed in the region of the endangered nerve or artery as the case might be. The excision was always done with the no touch technique and the instruments immediately discarded. The greatest care was taken to avoid contamination of the tissues from the wound and the excision was always carried out most radically, the aim being to remove all abnormal tissue, any sub-conscious fear about the subsequent difficulty of closing a very large wound being consciously and rigidly suppressed. The margins of



the new wound were then undercut just superficial to the deep fascia often to as much as 4 inches to allow of easy closure of the wound without tension. After hæmostasis had been secured, each vessel being carefully tied using fine catgut, the wound was carefully closed by suture using vertical mattress sutures and taking great care to see that the edges came accurately in apposition. In those cases where the wound could not be so closed without tension this was accomplished by the formation of a local rotation flap. By such means the wounds were always completely closed. In a few cases where sloughing of a localised part of the wound occurred, this was excised within seven days and a free graft applied. Free grafts were not used in the primary treatment. The aim was always to get the wound sutured completely without any tension and to have the edges accurately in apposition. A drainage tube was always left in for 48 hours. In limb wounds the part was carefully splinted and apart from the removal of the drain no dressing was done until the 10th day, when superficial sutures were removed and the 14th day when the remaining sutures were removed. The splint was then discarded and rehabilitation started.

I have investigated the results of 100 consecutive wounds so treated. They were mostly old wounds, the average time after wounding being 56 days. No case was less than seven days and none more than 300 days old. In size they varied from large wounds 10 - 12 inches by 4 - 6 inches to small wounds no larger than a two-shilling piece. The majority were of moderate or large size.

The results have been classified into four groups:—

- A. Healed by 1st intention like a clean surgical operation wound.
- B. Healed almost by 1st intention. Soundly healed in 14 days. No gaping in the wound but some stretching of the suture holes. Delayed primary union.
- C. More than 50% healed by 1st intention but part of the wound gaped.
- D. Less than 50% healed by 1st intention.

Of the 100 cases—50% showed Group A healing; 26% Group B; 15% Group C; 9% Group D. A and B may be taken as a highly satisfactory result, i.e. 76%. Even those of Group C who were not evacuated for other reasons were all healed in 35 days.

Apart from getting these wounds healed the object of treatment was to get the patients back to duty. Twenty-five of these cases had other lesions, e.g.

nerve lesion, amputation, or fracture unconnected with the wound treated, for which evacuation was necessary, or were prisoners of war and were evacuated for military reasons. The times of return to duty are therefore calculated from the remaining 75 cases.

The average time after operation of return to duty in Group A healing was 26 days: in Group B healing 39 days. All Group C returned to duty in 55 days. All Group D eventually healed and 33% returned to duty within 60 days.

One of the features of the treatment is that even in the unsuccessful cases where primary union is not obtained, because of the improved blood supply healing of the new wound is much quicker. No complications occurred in this series, apart from the failures of healing already detailed.

#### BACTERIOLOGY AND HISTOLOGY

In 33 cases the excised wounds were carefully cultured and examined histologically. The bacteriological findings and the relationship between the time of healing and the organism present are shown in the table below:—

		HEALING			
Groups:		A	B	C	D
STAPH. AUREUS	(12 cases)	6	4	1	1
STAPH. ALBUS	( 3 „ )	3	—	—	—
HÆMOLYTIC STREPS	( 3 „ )	3	—	—	—
B. PROTEUS	( 2 „ )	—	—	—	2
B. PYOCANEUS	( 2 „ )	1	—	1	—
DIPHThEROIDS	( 1 case )	—	—	—	1
STERILE	(10 cases)	3	1	3	3

It is curious that the best results were in wounds contaminated by staph. Aureus and streptococci. Although difficult to understand it at least demonstrates that it is possible to excise these wounds without contaminating healthy tissues.

Histological examination of the wounds shows extensive fibrosis involving frequently deep muscle. There were frequent foreign body giant cells around unabsorbed suture material. The blood supply to the centre of the wound was seen microscopically always very scanty. These results show what can be accomplished by aseptic surgery in the treatment of war wounds. They may be taken as a standard on which the combined attack on wounds by surgery and bacteriostatics may be judged.

## THE ROLE OF PENICILLIN IN WAR WOUNDS

by

Lt.-Col. F. H. BENTLEY, RAMC

and

Major SCOTT THOMSON, RAMC

(Read by Major Scott Thomson)

This subject will be discussed under three headings.

1. The value of bacteriostatics in control of infection at the first operation at C.C.S.
2. The value of penicillin in wound repair.
3. Local versus parenteral use of penicillin.

### 1. The value of bacteriostatics in control of infection at first operation at C.C.S.

In this Command for the last year wounds have been treated by a two-stage operation. At the first operation at C.C.S. grossly contaminated and damaged tissues are removed, and the wound is laid open so that there is free drainage and an absence of tension while the patient is being evacuated to Base. Several days later the wound is examined in hospital and is sutured if possible.

The main object of the first operation is the control of infection, and the subsequent progress of the case is determined by the success with which this object is achieved. No one with experience of war-wounds will deny that adequate surgery at the first operation is of paramount importance. After surgery is completed, however, some degree of infection is likely to remain, and it is in connection with this residual infection that a bacteriostatic may be of value.

It has been our custom for some years to put sulphanilamide into the wounds at the conclusion of the operation at C.C.S., but we have never been certain whether this was of value or no. With the advent of penicillin it was decided that a serious attempt should be made by means of a large-scale clinical trial to decide the precise value of these two bacteriostatics when employed locally in the treatment of recent wounds.

Such a trial has recently been completed from casualties occurring during the Gothic Line battle, and those surgeons who are present to-day and who were working in 5 Corps or in Ancona, Bari and Barletta during this battle will remember this investigation in which they played so active a part.

For those surgeons who were not immediately concerned in the investigation it is necessary to recapitulate the methods employed. The battle was fought in wet weather on cultivated ground. Casualties were heavy and C.C.Ss. were working under pressure. The treated wounds were therefore a fair sample of what could be expected from experienced forward surgeons under battle conditions. The difficulty of comparing one type of case with another was simplified since all external conditions such as terrain, weather, forward surgeons, lines of communication and base surgeons were the same throughout the period of the enquiry.

It was arranged with the forward surgeons in 5 Corps at the start of the battle that penicillin-sulphathiazole powder would be applied to wounds alternately with sulphanilamide, and that in a number of

cases no bacteriostatic would be employed. Penicillin-sulphathiazole powder was insufflated into the wounds so that a thick frost was produced. Sulphanilamide was generally applied "in bulk" so that the wound cavity was filled with the drug.

There were therefore, initially, three groups of cases, depending on the wound chemotherapy. It should be stated at the outset that the casualties in which no bacteriostatic was employed were carefully watched along the lines of communication and at Base Hospital. In no case was the wounded part endangered by this omission, and there was no instance of spreading sepsis.

The cases were evacuated from C.C.Ss. to Ancona, staged there and evacuated by ship to Bari area, arriving about the fifth to seventh day after injury. Within the next day or so they were taken to the operating theatre and the wounds were examined and sutured if possible. At this examination the clinical condition of the wound was noted and a woundswab was taken for bacteriological examination.

It will be useful here to define certain terms.

A clean wound was one that had the naked-eye appearances of a wound recently operated upon, and that showed no reactive changes.

A dirty wound was one in which the surface was covered by tissue exudates.

The term infection indicated only the presence of pyogenic cocci in a wound — staphylococcus pyogenes aureus or streptococcus pyogenes.

*Septic wounds.* Those dirty wounds that were infected with pyogenic cocci were called septic. About half the dirty wounds came into this category. These wounds are of importance because they are the ones in which the infecting organisms have "taken hold".

In addition to this examination of wounds on arrival at Base Hospital, swabs were taken from 100 wounds at a C.C.S. before operation was begun, in order to determine the original rate of infection in this battle. The swabs were examined by Major H. E. Hutchinson of No. 1 Mobile Bacteriological Laboratory, to whom we are indebted.

In this investigation about 900 wounds were examined. Staph. pyogenes aureus was found to be by far the most common pyogenic coccus. Strep. pyogenes (hæmolytic streptococcus) was isolated from 6 per cent. of all wounds and from only 1.5 per cent. in the absence of the staphylococcus.

In the 100 wounds from this battle that were examined in the operating theatre at C.C.S. before operation was begun, pyogenic cocci were found in 51 (figures provided by Major H. E. Hutchinson). This was the basic infection rate which surgery and chemotherapy had to combat, and the figure with which to compare the results of treatment.

These results were studied in 706 wounds in which the dressing had not been disturbed between operat-



ing theatre at C.C.S. and examination in Base Hospital. The rates of infection according to the chemotherapy previously employed were:—

Wounds treated at C.C.S.

by operation only, without bacteriostatic, 49 per cent. of a total of 116 wounds were infected.

by operation and sulphanilamide powder, 43 per cent. of a total of 213 wounds were infected.

by operation and penicillin-sulphathiazole powder, 25 per cent. of a total of 255 wounds were infected.

Thus, operation alone did not appreciably reduce the incidence of infection compared with the infection-rate before operation (51 per cent.), and the introduction of sulphanilamide into the wound produced little further improvement. The use of penicillin-sulphathiazole powder, however, caused a significant reduction in infection rate to one half of the pre-operation figure.

It is emphasised that the above figures refer to rates of infection as determined by a bacteriological examination of the wound. There was no correlation between the clinical appearance of the wound and the presence of pyogenic cocci, many clean wounds containing staph. pyogenes aureus and many dirty wounds yielding no pyogenic bacteria on culture.

Twenty per cent. of the undisturbed wounds were dirty, being covered with exudate, and about one half of these contained pyogenic cocci (septic). That is, the infecting cocci had taken hold. Of the wounds treated by operation only and without bacteriostatic, 23 per cent. were septic. In those in which sulphanilamide was locally employed, this incidence was reduced by half (11 per cent.); and in those treated with penicillin-sulphathiazole 7 per cent. of the wounds were septic.

If we show rates of infection and sepsis side by side, we see:—

#### RATES OF INFECTION AND SEPSIS IN RELATION TO CHEMOTHERAPY

	No.	Infected	Septic
Penicillin-treated wounds - - -	255	25%	19 = 7%
Sulphanilamide-treated wounds - - -	213	43%	23 = 11%
Wounds untreated with a bacteriostatic -	116	49%	27 = 23%

The precise value of operation and local chemotherapy in this series of wounds can thus be stated in the following terms. Operation alone, without the use of a bacteriostatic, did not appreciably reduce the incidence of infection compared with the original infection rate that followed wounding. This is what would be expected, for unless a mutilating excision was performed not all potentially infected tissues would be removed. The aim of the forward surgeon is to remove only those tissues that are grossly damaged, and by adequate incisions to leave the wound in the best possible condition for dealing with the infection that remains. The value of this treatment is seen in those wounds that were treated by operation only; although one quarter of them were septic, the sepsis was confined to the surface layers of the wound and there was no instance of the septic process spreading along the limb or tracking deeply.

Sulphanilamide applied locally had a bacteriostatic effect, for although the infecting bacteria persisted, their activity was depressed so that the incidence of sepsis was reduced compared with wounds in which no bacteriostatic was employed.

Penicillin-sulphathiazole powder had a greater effect, for its use was followed by the destruction of the pyogenic organisms in one half of the infected wounds and by an equally low incidence of sepsis.

It is therefore of value to use penicillin-sulphathiazole or sulphanilamide powder locally in the wound at the conclusion of the first operation at C.C.S.; and of the two bacteriostatics, penicillin-sulphathiazole is shown to be the more potent. Major Thomson and I hope that the surgeons from the C.C.Ss. in 5 Corps, and the officers in charge of divisions and their teams in the Bari area will feel that the results of this controlled investigation justify the extra work which they so enthusiastically put in towards this end.

## 2. The value of penicillin in wound repair

It can be accepted, we think, that penicillin will control pyogenic infection if it gets to the part in adequate concentration, and in the repair of wounds we use penicillin in three ways:—

Together with sulphathiazole as a powder.

As a solution, instilled into the wound through tubes.

Parenterally.

From the outset, the use of penicillin gave surgeons a feeling of security from the risk of spreading infection, and emboldened them to repair wounds at the earliest possible time, until at present in this Command almost all wounds are repaired on arrival of the patient at Base Hospital. This is but the re-establishing of an old procedure, although it may be that a higher proportion of success is obtained now that penicillin is employed. How much of the freedom from infection following delayed primary suture is due to surgery and how much to the use of penicillin is not yet known. There are many variables in wound-repair, and for this reason alone comparison of results with and without penicillin are difficult. There is, too, the important consideration, that the value of penicillin in wound repair can only be decided in relation to the infection of the wound at the time of repair. Thus, if 100 wounds were free from pyogenic cocci and were sewn-up without use of penicillin, Grade 1 union might well be obtained in 95 or so. If another 100 wounds all containing pyogenic organisms were sewn up with the use of penicillin, perhaps Grade 1 union would be obtained in 70 to 80. If the infectivity of the wounds at the time of repair was ignored, it would be concluded that wound repair was more successful without penicillin than with it. It is necessary, therefore, to make a comparison of penicillin with other methods in a large series of wounds in which the bacterial flora is known, before an answer is given to prove what we suspect—that penicillin makes certain a high proportion of success following wound-suture.

We could summarise our own opinions at the present time in the following three sentences:—

1. Penicillin has been shown to be a powerful bacteriostatic.

2. It should therefore be used as a routine in wound repair.



3. Its precise value in control of pyogenic value in wound repair has not yet been assessed.

Bearing these three conditions in mind, it is of interest to find that in a series of 715 wound-sutures carried out in the Bari area by specialists, graded-surgeons and trainees, and in which penicillin, was used as a routine, either by insufflation of powder at operation or by subsequent instillation through tubes, the result of suture was related to the presence of pyogenic cocci.

The figures are as follows:

In 614 clean wounds, 424 were free from pyogenic infection as revealed by a wound swab, and 85 per cent. obtained Grade I union (*i.e.*, 85—100 per cent. union), 190 were infected and only 62 per cent. attained the first Grade.

In 101 dirty wounds, 52 were free from pyogenic bacteria and 80 per cent. of these obtained Grade I healing; that is almost the same degree of success as was obtained in the suture of uninfected clean wounds. The 49 infected dirty wounds did not do well, only 37 per cent. reaching the first Grade.

This can only mean that even in the presence of penicillin pyogenic infection was not fully controlled. It may be that full control can be achieved with greater experience of penicillin therapy, but this remains to be proved.

### 3. Local versus Parenteral penicillin

The first conception of penicillin therapy taught that the ideal use of the drug was to give it parenterally, because in this way penicillin reached all tissues in adequate concentration. After some months experience in C.M.F. we began to have some doubt about this hypothesis. There were two reasons for our misgivings.

The first was that penicillin used parenterally did not in fact seem to reach all tissues. D'Abreu, Litchfield and Thomson pointed out that parenteral penicillin was of little avail in combating infection in the pleural cavity. It also became known that it was of equal unavail in the C.S.F. and inside joints. Apart from these special anatomical situations, there were sometimes conditions in a deep wound where the result of parenteral therapy was disappointing. Such a condition is well illustrated by the gun-shot wound that contains an open fracture. Inspection of such a wound usually reveals an extensive area of comminuted bone and considerable laceration and bruising of the surrounding muscles, which are lifted off the bone for a short distance so that a potential space exists around the fracture site. The whole area of damaged bone and muscle is filled with extravasated blood, and can be referred to as the "hæmatoma region." Only the clot lying in the wound cavity and the larger, loose pieces of bone in the surrounding muscle can be removed at operation. There remain numerous, more or less avascular bone particles in the fracture, and much extravasated blood among the bone fragments and in the damaged muscle. If bacteria are carried into this region by the missile, they can multiply out of range for the moment of the full effect of a blood-borne bacteriostatic that must reach them by transudation across the damaged area. They may therefore still be active when administration of the bacteriostatic is discontinued.

These observations imply that parenteral penicillin may not be effective in sterilizing infection lying in the hæmatoma region during the first week

or so after injury, and this is borne out in practice. For example we may quote two cases of through-and-through G.S.Ws. of the thigh with compound fracture of the femur and small clean flesh wounds. In one, the wounds were completely sewn up on the fifth day, and 600,000 units of penicillin given parenterally over five days. In the other, repair was done on the tenth day, and penicillin given for a week with a total of 840,000 units. In both the wounds united, but on the 15th to 21st day deep inflammation was evident, and pus discharged through the suture-line. Culture gave a growth of *staph. aureus*, penicillin sensitive. A sinus into infected bone developed later.

Similar observations have been reported by Furlong and Clark in their War Office report of May 1944. Bacteriological data are provided by Fraser *et alii*, who were able to examine fracture wounds in the middle of a parenteral course of penicillin. They describe three cases where, at the end of three days administration (360,000 units), swab of the fracture region revealed *staph. aureus*, penicillin sensitive.

This, and similar, evidence indicates that parenteral penicillin cannot be relied upon always to reach all parts of a damaged area.

The second reason why we began to question the routine use of penicillin parenterally was that a considerable number of strains of *staph. aureus*, the commonest cause of wound-infection, were found to be resistant to this form of treatment. In one experience, 20 per cent of strains of *staph. aureus* were resistant to the concentration of penicillin that parenteral therapy provides, *i.e.*, 1/10th unit per c. cm. But when the concentration of penicillin was increased a hundredfold, to ten units per c. cm., only half the so-called resistant strains continued to grow, and when the concentration was increased to 50 units per c. cm., few staphylococci would grow. Thus, while 20 per cent. of strains of *staph. pyogenes aureus* could fully resist the concentration of penicillin that obtains in parenteral therapy, many of these strains could be influenced by the increased concentrations that local therapy might provide.

For these two reasons that we have described, penicillin applied locally might be more effective than when given parenterally in many conditions. Three pieces of clinical evidence can be brought forward to show that this is in fact so.

1. *In open fractures.* In a consecutive series of 62 open fractures in which sufficient skin was available for closure, and in which penicillin was employed by local instillation through tubes, there were only two failures to achieve quiescent healing of soft tissues and bone, and these failures were not due to infection. As complete a control of infection in open fractures has not been obtained by parenteral therapy.

Hendry, Gledhill and Price also have reported that in 128 open fractures treated in the same way, infection was controlled in 63 per cent.

2. In the 715 wound-sutures that were discussed a few minutes ago, 190 of the clinically clean wounds contained *staph. pyogenes aureus*. Among these 190 strains of *staph. aureus*, 33 were "resistant". Suture of the 33 wounds, accompanied by the local use of penicillin, was followed by the same standard of union as was the suture of clean wounds infected



with "sensitive" strains. In other words, in the presence of local penicillin the staphylococci did not prove resistant.

3. We have already shown the value of penicillin-sulphathiazole powder applied locally at the first operation at C.C.S. During our observations of the casualties from the Gothic Line battle, 44 cases were collected who had had a 3 - 4 day parenteral course of penicillin at C.C.S. In 24 of these cases penicillin-sulphathiazole powder had also been applied to the wounds. Of these 44 cases 12 were found to be infected on arrival at Base Hospital, *ie*, about 25 per cent. The number is small, but it shows no appreciable difference in infection rate between those cases receiving penicillin parenterally and wounds treated with penicillin-sulphathiazole powder only.

These conceptions and results justify consideration of the use of penicillin in high concentration locally when such use is possible.

There are therefore three main conclusions from the evidence we have brought forward:—

1. Penicillin is shown to be an aid to surgery in the first operation at C.C.S.
2. It is believed, but not yet proved, that penicillin will control infection in wound repair, and make possible a high proportion of successful results.
3. Penicillin can, with advantage, be used locally in some situations.

## DISCUSSION

### *Brigadier Edwards*

I believe the work of Colonel Bentley and Major Scott-Thomson on the investigation of 1,004 wounds is the best contribution that has so far been made towards the assessment of the role of penicillin in wound treatment. We are very fortunate to have such a lucid account of a difficult problem from Major Scott-Thomson. This seems to be an appropriate time for discussion to start.

### *Major Shoreston.*

From the neurosurgical point of view we have had three groups of penetrating head wounds with torn dura. In the first group, penicillin was not used at all. In the second group, penicillin was used only locally. In the third group, penicillin was used both locally and parenterally.

In the first group of cases, 13 out of 84 died of sepsis. In the second group, with local penicillin alone, 11% were fatal. In the final group of 119 cases, the infection rate was 2.5%, and the death rate from sepsis was 8%. Out of 119 cases we have only lost one from sepsis.

I think that in the cases apart from penetration with torn dura, the results showed gradual improvement when penicillin was used. That applies both to the penetration with dura intact and the scalp laceration. The sepsis rate dropped from 8% to 2% in the scalp lacerations.

Finally I would like to say something about the type of cases which we thought penicillin is of use, at least in our branch of surgery. There is no doubt that it has a prophylactic use. In the problem of established infection results have been a little disappointing, not because penicillin has failed but because we have failed to use it correctly.

The most common form of sepsis we see is the almost malignant suppurative encephalitis. You

have, in addition to the inflammation, the effects of pressure, and we find it quite impossible in our cases to get the penicillin to the focus of infection. Out of 30 cases of suppurative infection, the mortality rate was 76% although treated with penicillin. They usually developed fatal ventriculitis and meningitis, I do think that parenteral penicillin in acute traumatic encephalitis is of very great importance, and I attribute to that the good results in the group of 119 cases. The sepsis rate was less than 1%.

### *Major MacPherson*

Colonel Moore's paper prompts me to report just now on the clinical experiment which Major Riddell and I carried out at No. 2 General Hospital on delayed suture wounds.

We are treating a series of wounds with and without local penicillin and have developed a method whereby deep wounds involving muscle to a considerable depth, can be examined bacteriologically as often as we wish during the first week after complete surgical closure without disturbing the wound at all and without, we believe, contaminating it in any way. It is a development simply of the principle of drainage from the very foot of a deep wound by a narrow tube down which, with full bacteriological precautions, the pathologist can obtain samples of the fluid at the bottom of the wound. This investigation is still in progress but the trend of it is giving us results rather like this. The wound which has been carefully closed surgically, and has been drained in accordance with the principles of surgery has a great capacity for healing no matter what organism is present. Like Colonel Moore, we have had complete success. It may be said in passing, these wounds had all been treated before with primary surgery and penicillin powder. To what extent penicillin has depressed the virulence of the organism present I am not prepared to say just now.

Secondly, we believe that the successful closure of wounds depends very much more upon mechanical factors than upon the bacteriological picture.

Wounds closed under tension are well known to be liable to break down. We have found sutured wounds in the perineum and axilla also tend to break down.

In the penicillin wound we have demonstrated the disappearance of gram positive cocci after the wound is closed, but we have had as well, cases treated by penicillin which though appearing to heal completely, break down afterwards. We found one break down with copious discharge of pus in which there was a growth of coliform organism, the same organism was recovered from the penicillin which had been injected into the wounds. I think it is very important that the local use of penicillin should be done with the greatest asepsis, and that the principle of asepsis must be hammered into all those using penicillin in wards and departments. The fact that a gram negative bacillus which eventually may cause breakdown of the wound can grow it is, I think, not sufficiently appreciated by many of those who have to do the treatment.

### *Colonel Gillespie*

One of the previous speakers has mentioned the use of penicillin in transportation. It may be of interest to know that some work has been going on in the United States for the past few months on the administration of penicillin in an emulsion

of peanut oil with 3 or 4 per cent beeswax. That suspension holds up the absorption of penicillin very satisfactorily, and a demonstrable blood level can be shown 14 hours after initial injection of the penicillin in doses of 150,000 units. This treatment has been generally used in venereal disease. Gonorrhœa is treated with a large single dose of penicillin in the dosage mentioned, and the percentage of cures is approximately 100 per cent. Initial injection of 125,000 units gave a few failures, but when the amount was increased to 150,000 units these cleared up, and there were no failures. Syphilis, previously treated on 7½-day course with 64 injections, is now treated with a daily dose of the same amount. The results are just as satisfactory as they were previously. This method has not, so far as I know, been tried in cases of battle casualties. It would appear to hold considerable promise.

#### *Major Donovan*

In my hospital we have just done a series of 500 delayed primary sutures with very gratifying results. When we came to examine our failures, we found that the large majority of them were confined to hands and feet. We found these hands and feet were arriving for delayed primary suture about the fourth or fifth day, but the skin was sodden like blotting paper, making a satisfactory suture almost impossible. We tried dressing them with various substances to get the skin hard again, but even so the results of delayed primary suture were not satisfactory. About that time vaseline gauze was being used as a dressing almost exhaustively, and I spoke to Brigadier Stammers about it, and he very kindly had this stopped. The hands and feet then began to arrive in a somewhat better condition,

but still a very large number were arriving with the skin so sodden that a delayed primary suture was almost out of the question. It seems that this soddening of the skin is entirely due to the skin secretions themselves. We all know that secretions of the hands and feet are copious at all times and more copious in times of pain or times of stress. My own palms are sweating freely at the moment! It is, we feel, a very real problem to know how to splint adequately the hand and feet, and still do it in such a way as not to retain these secretions, and how to get them back to a base hospital with the skin in a fit condition for us to do a delayed primary suture. I have been quite unable to solve this problem, and I wonder if any of the surgeons at this meeting who have been confronted with the same problem can give me any help in the matter.

#### *Major Blackburn*

Regarding doubtless amputations, I was very interested in what Colonel MacDougall said. I have had only one or two myself, and I have seen one or two of my colleagues'. I think it fair to say that everybody is disappointed with the result of the evacuation of men with double amputations, so much so, that in the last two or three cases I have dealt with, I have retained them forward for a few days and done the delayed primary suture of the amputation stumps myself. I believe that this has a place. I believe that it is psychologically good, and I believe that it is not only easy to do it, but that it is easy to get the patient's confidence and to send him back to the base with amputation stumps that will allow of quicker evacuation from this theatre, and eventually save time in the application of the artificial limb.

## WOUNDS OF THE SCALP

by

Capt. F. J. GILLINGHAM, RAMC

### **Introduction**

When we think of the minor wound at all in the light of economy of man-power, it takes a place of increasing importance, for, if treated well, it will lead eventually to the least disability. This is certainly true of the scalp wound. Efficient surgery, carried out within 24 hours of wounding, will return a man to duty within ten days, in 95% of cases. Delay in treatment by evacuation down the line when more serious cases demand the most attention will invariably result in sepsis. Sepsis in the scalp, certainly before the days of penicillin, will keep a man in hospital for two or three weeks, irrespective of complications. He loses his unit, his friends, and his adaptation for battle, factors which can be the basis of malingering and neurosis.

During the last seven months the Neuro-Surgical Unit on the Adriatic side has admitted some 2,000 neuro-surgical cases and, with the help of the general surgeons in peak periods, has returned to duty some 600 men suffering from wounds of the

scalp. Primary healing occurred in 95%-98% of cases. We have encouraged that all head injuries should be sent to the Head Centre, mainly for the purpose of sorting, for all missile wounds of the head and face require X-ray of good quality, if penetration of the cranium is not to be missed.

### **Classification**

Scalp wounds according to the mode of injury fall easily into two groups.

*The first.* Those due to missiles, metal fragments, wood, glass and stones. The scalp is guttered or punctured according to the direction of the missile. Hair and portions of the hat are carried into the wound with it. This type of injury is seldom associated with a traumatic amnesia, or with abnormal neurological findings, although in a few cases of "gutter" scalp wounds from bullets we have seen transient hemipareses, hemianopias, and hemian-aesthesias.

*The second group.* Those due to blunt objects, from traffic accidents, or falling rubble. The scalp is "split", and presents itself as a bruised, ragged,



linear wound, with off-shoots and tags, with debris and hair indriven and often swept underneath the wound edge. Occasionally a complete flap of scalp is avulsed from the bone.

This type of injury is more often associated with a traumatic amnesia of varying duration, but usually without abnormal neurological signs.

### Investigations

From what we have said, certain investigations are obviously necessary before operation is considered.

- (1) The history of injury and the length of amnesia.
- (2) General examination for associated injuries.
- (3) Mental examination for evidence of concussion.
- (4) Neurological examination for focal signs, and finally.
- (5) Radiological examination. It is to be remembered that wood, glass and stones are all non-opaque to X-rays, and we have found each of these in the brain from time to time. To render treatment as foolproof as possible, all scalp wounds should be X-rayed, probed and explored.

### Treatment

We have found that the preparation of the wound for operation is best carried out in a room set aside for that purpose. The scalp is shaved for at least three inches around the wound and all long hair cut short. The orderly must always wear a mask while the wound is exposed and the preparing is going on. Regional block local anaesthesia was invariably used unless the wound involved the region of the ear or eye, when general anaesthesia was given. A basal narcotic such as alopon and scopolamine intravenously made the procedure easy for both the patient and the surgeon. Full aseptic technique in a theatre is essential. The scalp is cleaned carefully with soap and water, and the wound isolated with sterile towels. In order to plan the lines of excision parallel with the track of the missile, it is a wise precaution to probe the wound to ascertain its direction and the depth of the foreign body.

The wound is excised boldly with vertical excisions to the bone just wide of bruised tissue. If side-shoots cannot be excised with the main wound, they are taken separately. Each layer of the scalp must then be examined for bruised tissue, and excised if not included at first. At the same time, the scalp is not very elastic, and too bold an excision may jeopardise the closure. Bleeding is controlled by finger pressure, and then by artery forceps applied to the galea and thrown back over the scalp, or by means of self-retaining retractors.

All dirt, hair and the foreign body are removed, and the wound thoroughly cleaned out by washing and wiping. Undermined flaps of scalp or pericranium must be examined carefully for dirt and underlying fractures.

Scoring of the outer table with ingrained dirt is best treated by scraping with a sharp rougine.

Finally, penicillin and sulphathiazole powder is insufflated as a hoar frost, and the wound closed in two layers with fine waxed silk and no drainage. The galea aponeurotica forms the deep layer and

is closed with interrupted sutures cut close to the knot, while the skin is closed with interrupted sutures or a continuous suture.

The two-layer method of closure gives better haemostasis and more approximation, and therefore a greater chance of primary healing.

The wound should be closed without tension as far as possible. If closure is difficult, undermining in the layer between the galea and pericranium will usually solve the problem. Plastic procedures may be necessary, and these should always be adopted if there is a danger of bare bone being left exposed in an open wound. Bare bone seldom granulates over and often dies. In practically none of our cases did we fail to close the wound completely.

Vaseline gauze dressings tend to keep the wound moist, and we have always used a gauze pad applied firmly over the wound with a bandage. The dressing is removed without discomfort or sticking on the third day, when the sutures are removed.

### Special Features

If temporal muscle is involved, it is excised conservatively with its fascia in the direction of this fibres and the wound treated as before. If possible, the temporal branch of the facial nerve should be spared to avoid paralysis of the frontalis muscle. Lines of excision made parallel to the course of the nerve usually spares its destruction.

Minute metal foreign bodies in the scalp are on the whole better left, unless there is doubtful involvement of bone.

Multiple scalp wounds, such as arise from grenade or mine wounds, are a difficult problem, for quite often, one of them at least, is of a serious nature. Good X-rays are essential and those wounds under suspicion should be explored. The simple wounds are cleaned out with a spoon, and all foreign material removed.

### Post-Operative Care

The post-operative care and disposal of the simple scalp wound can be summarised as follows:—

After operation, bed rest until the next morning when the patient is encouraged to resume normal activity. No chemotherapy is given, and on the third day the sutures are removed, and the wound redressed only if the stitch holes bleed. Dressings can be dispensed with anyway on the fourth day, when the patient is sent to the Convalescent Depot for graduated exercise and recommendation for return to duty at the latest, on the tenth day.

For the adequate treatment of minor wounds in the forward areas, Convalescent Centres fairly well up are essential, and we have been fortunate in having these facilities, for at times, owing to the demand for beds, cases have been sent the day following operation and the sutures removed there.

### The Septic Scalp Wounds

Casualties arriving from the Balkans in which sepsis was the rule rather than the exception, stimulated fresh thought with regard to their treatment. Some 20 cases were treated in the following manner. The suppurating wounds, in the absence of surrounding inflammation, were excised boldly through clean tissue to bone, the whole

wound or sinus with its foreign bodies being removed in one. Absolute hæmostasis was obtained (normally with diathermy), and the wounds sutured in one layer without tension as far as possible. The burying of silk in these wounds was contra-indicated in view of the sepsis.

No post-operative chemotherapy was used, and the sutures were removed on the sixth day. The

common organism was the staphylococcus aureus.

Primary healing was amazingly high and a conservative but rough figure is in the region of 90%. This is an approximate figure. The presence of cellulitis of the scalp around wounds presented contra-indications to immediate surgery, and was dealt with rapidly by means of a three day course of i.m. penicillin 15,000 3-hourly.

## PRIMARY CLOSURE OF BATTLE WOUNDS OF THE FACE

by

Capt. REX LAWRIE, RAMC

### Introduction

This is an account of the methods used and results of primary closure of battle wounds of the face, which has been our routine practice for over a year. Previously, most of the wounds were several days old and infected when they reached us, so the only treatment then possible was a regime of careful ward toilets and often several sequestrectomies of maxilla or mandible, until healing by granulation was complete, usually in 2-3 months. One to four weeks later, a formal scar-correction was done.

In January 1944, a detachment of the team established a forward base at Naples, and we had the opportunity of treating fresh battle-casualties often within a few hours of injury, thanks to a most efficient organisation for sorting and evacuation of cases. We then embarked on a policy of early closure of practically all facial wounds, which has increased in scope ever since.

### Advantages

1. *Quicker recovery.* Simple, uncomplicated soft-tissue wounds are able to return to duty as soon as the sutures are out, with minimal scar. As is shown in Table II, the average stay in hospital is four and a half days for minor closures, six days for major ones. Closure shortens the incapacity period from even the smallest wounds and the cosmetic result is better.

2. *Reduction of ward work.* Where complicating injuries make the patient a long-term case, primary soft-tissue closure is a great boon. No dressings are needed after the first few days and this is a help to the ward staffs and saves the patient a great deal of suffering and discomfort.

3. *Fewer complications.* In cases involving bone, successful closure prevents bone infection, with its chronic discharging sinuses, sequestrectomies and acute inflammatory episodes. The stage of disfigurement which used to last weeks or months is reduced to a matter of hours.

4. *Optimum time.* There is no doubt that closure of buccal and other fistulas at primary operation is easier and more successful than at the late stage when the wound is fibrotic.

### Technique of Early Closures

If any facial wound is allowed to heal naturally a scar will result and it is commonly agreed that

the only way to avoid scarring from facial wounds is to suture a vertically cut skin edge into exact edge apposition over a bed of normal subcutaneous tissue, with perfect hæmostasis, no tension and no infection; then to remove the stitches in two or three days. For a satisfactory result, there must also be no distortion of the features. That is the basis of all scar-corrections.

A similar procedure can be used to close the wound at a primary operation. Under local anaesthesia, a wound toilet is done, the skin edges excised and undermined and hæmostasis secured by hot flavine packs. A subcutaneous tissue layer is then fashioned and closed with catgut, the skin accurately sutured and a pressure bandage applied. The amount of skin excised is not more than would be sacrificed were the wound left to heal and a formal scar correction done. The obvious difference is the danger of infection and it has been found that 48 hours from injury is near the upper limit of safety in the majority of cases. Up to that limit, primary healing in three days may be consistently achieved. The cosmetic standard is generally good, but not quite so good as that of cold scar-corrections done under ideal conditions.

In battle-injuries, the nasal and buccopharyngeal cavities, maxillary and frontal sinuses, mandible, hyoid and zygoma are very commonly involved and experience has shown that these too may be closed with consistent success, after a very careful toilet with removal of all loose bone fragments and tissues of uncertain vitality, remembering that any dead tissue left behind is almost sure to suppurate. In antral closures there is generally a gross traumatic nasal antrostomy; if there is not, it is wise to make one before closing the external wound. In cases of mandibular comminution involving tooth sockets, bone suppuration is common and it is often wise to drain the wound. It is very important to cover exposed bone with soft tissues to prevent bone infection.

A post-operative course of oral sulphathiazole, G.1, 4-hourly for four days is given as a routine.

Most of the cases here reported were operated on in a tented theatre, without using gowns or gloves; in any case many wounds involved the buccal or nasal cavities. In spite of this, sepsis has been conspicuously absent.



## Limitations

The method is sometimes inapplicable to grossly abraded wounds with much skin contusion in sites where skin can ill be spared. Mere skin-loss is no contra-indication, as partial closures usually hold and split-skin grafts can be used to close the residual skin defect. As a rule, wounds that are obviously infected or over 48-hours old are unsuitable for primary closure.

One other difficulty is that it is often necessary to fit dental splints for jaw fixation within a day or two of the injury and the manipulations involved endanger the newly healed suture lines. The risk of breakdown can be eliminated by a few large-bite, deep, stout silk sutures embracing the suture-line, which are removed at the end of the operation.

TABLE I  
*Analysis of 8 weeks' work*

Total No. of cases treated: 379 (Jaw fractures: 89)  
Total No. of operations done: 270  
Cases on whom primary closures were done: 140.

It will be seen that over half the operations done included primary wound closures.

TABLE II  
*Analysis of primary closures*

Total	Returned to duty	Evacuated	Death
Major alone 21	11 after av. 6 days 2 (infected) after 12 days	8	0
Compl 41	0	40 (20 jaws)	1
Minor alone 59	53 after av. 4.3 days 3 (infected) after 11 days	3	0
Compl 19	0	18 (10 gensurg)	1
Total 140			

## Results

Table II analyses the results of these closures. In this table, a major closure is defined as one involving a compound fracture or antral or buccopharyngeal cavities. The rest, however large or extensive, are classed as minor. For instance, one case in the series had four lacerations of his face, totalling a suture line 12" long; another had a 6" missile track involving parotid gland and pinna of ear, with a 4" suture line on his face. These were both fit for duty in six days. "Complicated" implies a complication which inevitably makes the case a long-term one for evacuation to base. Multiple closures on the same patient are counted as one case. All cases were held until the stitches were out and the danger of immediate infective complications past. They were then evacuated to the main section of the unit if there was no reasonable prospect of return to duty within a week. It will be seen that 60% of major and 95% of minor uncomplicated closures were returned to duty without evacuation to base; and

that in this series, 64 battle casualties of the face, treated by primary closure, were returned to duty within a week of wounding.

One of the two fatal cases in the series died of bronchopneumonia. In addition to a fractured mandible, he had blast lung and abdomen and penetrating wounds of eye and knee joint. The other was a case of death from toxæmia from multiple severe septic mine wounds. A 3" face wound had been closed under local anæsthesia.

## Role of Penicillin

In all the major closures and about half the minor closures in this series, penicillin-sulphathiazole powder, G.4—1 was smeared throughout the wound. A previous series of similar cases was done in Jan-April 1944, without penicillin or other local chemotherapy and it was hoped that they would provide a control series. However in some important respects they are not strictly comparable; most of them were operated on much later and many were really secondary closures.

The effect of penicillin is not immediately spectacular and cannot be statistically proved by this series of cases, but the following observations emerge from a study of the records:

1. Closures of antral and other compound face wounds, GSWs of mandible etc can be done successfully with or without the use of penicillin.

2. Local penicillin definitely reduces the incidence of stitch infection and cellulitis of the face in the region of a major primary closure.

3. Thus the standard of the successes is raised; but their proportion and the scope of major primary closures is not much affected.

## Summary

1. Judicious careful excision and primary suture with the proper materials is of great benefit in facial wounds.

2. For slight wounds it gives the prospect of return to duty with good cosmetic result in 95% of cases in an average of 4-5 days.

3. It produces rapid healing of the major wounds safely, with least chance of late infective complications and shortens the period of deformity and pain from a matter of months to days.

4. This applies particularly to antral wounds.

5. Local application of penicillin-sulphathiazole powder is of slight but definite value.

## Acknowledgments

My thanks are due to Major P. W. Clarkson, under whose direction this work was conceived and done, to Major T. H. H. Wilson, A.D.C. Corps, for his co-operation and first class dental work, to Major G. K. T. Roche, RAMC for his skill in anæsthetising these difficult cases.

(Twenty sets of photographs were shown on the epidiascope, illustrating methods and results of facial primary closures).

# SUMMARY OF THE RESULTS OF WOUND CLOSURE AFTER GOTHIC LINE BATTLE

by

Capt. G. PARISH, RAMC

On the instruction of Brigadier Edwards I summarised the result of delayed primary and secondary sutures done in 20 General Hospitals and 1 F.S.U. during the period September-October 1944. Mainly Gothic Line battle casualties. These I will present to you as briefly and concisely as possible.

Firstly, let me define my terms, delayed primary and secondary. The former, i.e., "delayed primary", was taken to include all wounds sutured within 12 days of the primary excisions, and the latter, all wounds sutured from the 13th day onwards.

The results were divided into four groups:—

1. 100% — 90% healing, i.e., a successful suture.
2. 50% — 90% healing, i.e., a partially successful suture.
3. Under 50% healing, i.e., an unsuccessful suture.

The total number of wounds surveyed was 3845, and these included fractures as well as flesh wounds.

The method of suture in over 90% of the cases reported, involved the use of penicillin, either by insufflation, intubation or parenterally.

The overall summary is given in Table I.

TABLE I

	Success.	Partial Success.	Failure
Delayed Primary Suture . . . . .	2693 78 %	537 16 %	205 6 %
Secondary Suture . . . . .	276 67 %	96 24 %	38 9 %

Here you will note that the results of delayed primary sutures are better than those of secondary sutures.

These results are subdivided into those of purely soft tissue wounds and those of soft tissue and fractures, and they are shown in Table II.

TABLE II.

		Success	Partial Success	Failure
Delayed Primary Suture	With Fracture	311 73 %	79 18 %	39 9 %
	Without Fracture	2382 79 %	459 15 %	166 6 %
Secondary Suture	With Fracture	44 64 %	20 29 %	5 7 %
	Without Fracture	232 68 %	76 22 %	33 10 %

In each group the presence of a fracture lowered the percentage of success.

A thousand consecutive proformae were taken in which all the time factors had been correctly given. The success rate for the three time groups was determined as shown in Table III.

TABLE III.

Time Lag Wounding-Primary Excision	Time Lag Primary Excision-Delayed Suture	Success	Partial Success	Failure
Under 24 Hours	Under 6 Days	495 78 %	83 13 %	54 9 %
	6-12 Days	187 70 %	55 21 %	23 9 %
24-48 Hours	Under 12 Days	74 73 %	22 22 %	6 6 %

i.e. better results were obtained as those cases where the delayed sutures was performed in the first six days.

It must be borne in mind, however, that no account is taken of those wounds unsuitable for suture. Brigadier Edwards estimates that 70% of open fractures and over 90% of soft tissue wounds were sutured in the period under review.

The success rate in relation to site of wounding was also determined, but here again the figures must be assessed in the light of the same criticism.

TABLE IV.

Results of delayed primary suture of 1,000 wounds (including fractures) in relation to site.

Site	Success	Partial Success	Failure
Neck . . . . .	8 100 %	0 0 %	0 0 %
Head . . . . .	8 89 %	0 0 %	1 11 %
Shoulder . . . . .	48 88 %	3 6 %	3 6 %
Leg . . . . .	153 79 %	24 12 %	18 9 %
Foot . . . . .	22 78 %	3 11 %	3 11 %
Trunk . . . . .	85 77 %	16 14 %	10 9 %
Forearm . . . . .	54 77 %	9 13 %	7 10 %
Thigh . . . . .	231 75 %	48 16 %	27 9 %
U. Arm . . . . .	91 70 %	30 23 %	9 7 %
Hand . . . . .	11 69 %	4 25 %	1 6 %
Buttock . . . . .	51 69 %	14 19 %	9 12 %



The number of head, neck and hand wounds is too small to warrant any conclusions. Causes of failure of certain wounds were interesting, and can be briefly summarised as follows:—

1. Under tension at the suture line.
2. Flare up of infection in the depths of the wound.
3. Infection of tube or stitch holes.
4. The presence of subcutaneous dead space, or tenting.
5. Inadequate hæmostasis with clot formation.

6. The presence of a subjacent fracture (*e.g.* tibial shaft), foreign body or loose bone.

7. Associated diffuse gross muscle trauma.

8. Associated large vascular injury.

9. Inadequate excision at primary operation.

10. Sharply angled skin flaps of doubtful viability which became non-viable on mobilisation and suture.

In conclusion, let me add that no bacteriological summary could be made as there were insufficient swab results reported to justify any surveys.

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Tuesday, 13<sup>th</sup> February 1945

AFTERNOON SESSION

**Subject:**

**Wounds of the Chest**

*Presiding:*

Major-General Hartgill, C.B., O.B.E., M.C., K.H.S.,  
Director of Medical Services,  
*AFHQ*





# THE SURGERY OF LODGED INTRA-THORACIC MISSILES

by

Lieut-Colonel A. L. D'ABREU, RAMC

Colonel Churchill (1944) has recently said that the surgeon's focus of attention has moved from the pleural space to the lung in World War Two. Although the removal of missiles from the chest is by no means the chief surgical task in the care of chest wounds it is worthy of discussion because there is a widespread impression that British surgeons do not favour the removal of intra-thoracic missiles. Of the last 719 chest casualties discharged from the thoracic wards of this hospital 137 missiles have been removed by thoracotomy or mediastinotomy. Such surgery can only be justified if the risks of leaving the missiles is greater than the operative mortality or causes a higher morbidity. Metallic foreign bodies may cause immediate or late complications. In an active theatre of war little opportunity exists for the study of late cases: complications were relatively common in the case of unremoved missiles of the last war according to the evidence of J. E. H. Roberts, and C. Price-Thomas who have spoken of the late sequels of hæmoptysis, lung abscess, bronchiectasis and empyema in such ex-soldiers treated at Rehampton. Grey Turner in 1919 said in a paper on the "Later Stages of Gun-shot Wounds of the Chest (1919)": "I am more and more impressed with the general truth of the proposition that sooner or later a foreign body, where ever situated, tends to give rise to trouble".

Of immediate complications in the earlier weeks I have seen death from lung hæmorrhage twice in non-operated cases, hæmoptysis on several occasions, empyema associated with peripherally placed lung missiles — ten times, abscess cavities on a similar number of occasions and twelve empyemata associated with large shell fragments lodged in pleural cavities. Of retained mediastinal missiles at least six have been associated with abscess formation — of these three were cured by early operation before the mischief had spread, two were operated on late when empyemata and vertebral body osteomyelitis were already present and the third was associated with an œsophageal-pulmonary fistula that ultimately proved fatal. A less serious problem is the missile impacted in the endo-thoracic fascia deep to the rib plane but extra-pleural. In addition to causing pain these fragments have been associated in seven of our fifteen cases with quite considerable extra-pleural abscesses. The association of infection with missiles lodged here and in the loose tissues around the œsophagus in the posterior mediastinum is comparable with similar infections around metal lodged anywhere in the body in loose connective tissues.

Because of these potential complications and because the harbourer of a lodged missile is naturally anxious about his state until the metal has gone, it has been our practice to remove retained missiles of one centimetre or more in size.

The following table indicates that such operations carry less risk than the policy of non-intervention.

**Retained Intra-Thoracic Missiles - 208 cases**

	Lung missiles	Pleural Missiles	Mediastinal and Cardiac Missiles	Missiles in endo-thoracic fascia
Total number. . . .	134	27	32	15
Number operated on and removed . . .	71	26	17	12
Number operated on and not removed	2	Nil	3	Nil
Deaths (Post-Operative). .	2	Nil	2	Nil

## The Deaths

The post-operative thoracotomy deaths in the lung missile series were in patients with other grave lesions. Both had huge metal fragments over 4 c.m.'s in size: one died six weeks after operation from septicæmia due to a penicillin resistant staphylococcus; severe buttock wounds complicated this chest wound. The other had a shell wound abscess of the brain operated on by a neuro-surgical unit prior to admission and an infected pericardial effusion. It is not unfair to say that both would probably have died even if not operated on. The two mediastinal deaths are detailed below. Both were cardiac injuries.

## Number Operated on and Missile not Removed

Of the two lung missiles not removed at operation each was associated with a large infected clotted hæmothorax. The operations were chiefly for the evacuation of these and a deliberate search was not made for missiles. Of the "failed" mediastinal operations, in one a large foreign body lay in the inter-ventricular septum. After the pericardium was opened it was seen that the missile was only removable with the gravest risk of hæmorrhage because the left ventricle wall had been badly damaged and would not have held sutures; death followed from heart failure. The other death was an unexpected one following the removal of a foreign body from the pericardium which also lay partly in the left myocardium. An autopsy failed to reveal the cause of the sudden heart failure.

It can be said with honesty that no death has followed the removal of an uncomplicated missile except this latter case. The two other unremoved missiles were so placed in the mediastinum that removal would have been more dangerous than abstention: one would have entailed unjustifiable risk to the inferior vena cava and another lay deep in a vertebral body behind the aorta in a patient with an empyema.

## The Complications of Operative Removal

### (a) Operative

No serious complication such as hæmorrhage has been encountered. On one occasion a missile lay so impacted in the lower lobe bronchial wall that lobectomy was required: The patient made an excellent recovery. The chief anxiety is usually that of bronchial obstruction by blood or mucus: if the bronchi are at all wet at the close of operation bronchoscopic suction is necessary and is done.

### (b) Post-Operative

The post-operative course is usually surprisingly good. Atelectasis, so common after abdominal operations, is not frequent. It has never occurred on the contra-lateral side. Four post-operative empyemata have been seen after removal of lung missiles but none were serious problems. This in spite of our practice of avoiding pleural drainage except where missiles are removed in the presence of frank empyema. The mental relief of the patient after removal of the foreign body is striking.

## Selection of Patients for Operation

The safety of these major surgical operations depends on several factors. Hastily conceived and inadequately planned operations are dangerous. The time factor, the avoidance of deliberate operations until the disordered physiology of the chest and of the circulatory system have been corrected, the radiological assessment not only of the exact site of the missile but of coincident lung pathology and the provision of absolutely safe anaesthesia are all of equal importance. In this theatre the generally accepted conception of the two-stage operation for wounds is most applicable to the chest casualty: at the primary urgent operation the disordered physiology and potential infection are corrected by surgical closure of the sucking pneumothorax after as adequate an excision as elsewhere, in addition to resuscitation and the careful aspiration of hæmorthorax. Fortunately, the freedom of lung tissue from gas gangrene infection and the dangers of post-traumatic tension absolves the surgeon from any excision responsibility towards the parenchyma itself. Conscious of his primary duty and of the handicap of not having precise radiology available, the forward surgeon does not shock his embarrassed patient by a thorough search for lodged missiles unless these are clearly close at hand, but devotes himself, as in other wounds, to the performance of the first stage of the operation.

## The Time Factor

The ideal time for formal thoracotomy or mediastinotomy is about 7-14 days after wounding. This rather dogmatic choice is made on three assumptions:

- (a) That in this period severe physiological disturbances such as a sucking open pneumothorax and those that follow a hæmorthorax, or hæmo-pneumo-thorax and those of surgical shock have been adequately corrected.
- (b) The dangerous period of complications such as a lung or pleural infection, the organisation of hæmorthorax clot and the development of broncho-pleural fistulae has not yet arrived.
- (c) Radiology and specialised anaesthesia are more likely to be available at a special centre than in a forward unit.

## The Radiological Assessment

A radiologist experienced in thoracic work can readily locate missiles and indicate the presence or absence of such complications as lung abscess, lung track, atelectasis, hæmorthorax or mediastinal involvement. He can locate the missile in terms of lobe position, relation to fissures, and its depth from the surface. In this hospital the exact anatomical approach to the metal is decided in the X-ray conference room after a study of postero-anterior, lateral and tangential films combined with an evaluation of the screening findings. There should rarely, if ever, be doubt as to whether the metal lies in lung, heart, mediastinum or endothoracic fascia. It may be mentioned here that intra-cardiac missiles of small size are quite easily overlooked in the absence of careful screening. Exact markings are made of endo-thoracic fascia missiles and the final appeal to radiology is on occasions made in the theatre where the metal is located by means of parallax after the chest has been opened and a needle placed directly on the object. This is of particular value when the metal is surrounded by hæmotoma formation or calcified glands near the hilum and is therefore difficult to palpate with exactness. The presence of missile tracks as seen on the radiograph has been much studied by Major Hodson, my radiological colleague and the pre-operative estimation of these provides a useful guide at operation, for such tracks are often palpable and logically a finger following their course should end up at the missile. With increasing experience the least difficult of our tasks is the radiological localisation and no metal fragment has been left because its exact location was unknown.

The reasons for the odd "failure" have been surgical, *i.e.*, missile in too dangerous a site to remove, or deeply embedded in lung in association with a pleural empyema.

## The Surgical Technique

(a) Lung missiles. (b) Pleural missiles. (c) Mediastinal and cardiac missiles. (d) Endo-thoracic fascia missiles.

## Certain Factors Common to All

### (1) THE ANÆSTHESIA

Pentothal induction followed by intra-tracheal cyclo-propane is our routine method. Carbon dioxide absorption keeps the breathing quiet and unlaboured. Controlled respiration is used whenever necessary. Positive pressure anaesthesia is not used, nor do we practise forcible inflation of the lung at the close of thoracotomy as there is always a risk of forcing plugs of mucus and blood deep into the bronchi: we prefer to take off air gradually with an artificial pneumothorax set after the chest has been closed.

### (2) PREFERENCE OF RIB RESECTION TO INTER-COSTAL INCISION

Thoracotomy through the bed of a resected rib is preferred because the chest wall closure is easier, the incised periosteum being easily sutured, and because of the lessened incidence of post-operative inter-costal pain. Peri-costal sutures are never employed.

### (3) DRAINAGE IS AVOIDED WHENEVER POSSIBLE

Careful post-operative aspirations combined with penicillin instillations (when indicated) are used in preference to drainage except for grossly infected pleural cavities or mediastinal abscesses.



**(4) PENICILLIN****(a) General penicillin**

This is used prophylactically if thoracotomy is to be done in the presence of chest wall sepsis or of lung infection, *e.g.* abscess seen radiologically but not for intra-pleural infections, which always respond better to intra-pleural penicillin than to general penicillin.

**(b) Intra-pleural instillations**

If at the close of a thoracotomy there is much infection around the missile or there is pleural infection, 120,000 units in 20 c.c.s of fluid are left in the cavity after chest closure and air aspiration. Its post-operative use is controlled by the bacteriological examination of aspirated post-thoracotomy effusions.

**(c) Local powder**

The bed of the missile after the latter has been removed is insufflated with penicillin and sulphathiazole powder. In the case of the lung missiles the bed is obliterated by catgut suture.

**(A) Removal of Lung Foreign Bodies**

The approach depends on the radiological localisation.

"Classical" thoracotomy is not always possible and four different approaches have been employed. Classical thoracotomy through the 7th and 8th space, usually after resection of a long length of rib, is the commonest approach. The incision is placed more anteriorly or more posteriorly according to radiological localisation—antero-lateral or postero-lateral thoracotomy. For wide exposure we use the Tudor Edwards rib spreader; otherwise the single Tuffier retractor suffices.

Anterior thoracotomy is employed for missiles lying in the anterior half of the lung and for the approach to the anterior mediastinum. A rib is resected; if more room is required, one or more costal cartilages are divided and the space is widely retracted.

Sub-scapular thoracotomy is reserved for missiles lying towards the posterior aspect of the upper part of the upper lobe. A portion of the 4th or 5th ribs is resected and the space widely retracted with Tuffier's retractor.

The small inter-costal incision is used for superficial lung missiles and for some pleural foreign bodies; also for missiles localised by needle contact done radiologically before operation. With rib spreading a surprisingly good exposure can be obtained.

Once the pleural cavity has been opened, the course of operation depends on what has been found. Adhesions are usually divided in the region of the lobe lodging the missile, unless the latter is readily palpable. Occasionally adhesions have presented considerable difficulty, though rarely comparable with those encountered in lobectomy for bronchiectasis. After mobilisation the lobe is held up in the wound by Duval's lung forceps.

**Removal of missile and post-operative management.**

Once the missile has been palpated, the lung is incised with a knife (diathermy is not available) and, rather after Hilton's method for abscess incision, the hole in the lung is enlarged and the metal withdrawn.

Lung vessels have twice required ligation. The foreign body bed is then insufflated with sulphathiazole-penicillin powder and the dead space obliterated with a few catgut sutures. After pleural toilet the chest is completely closed without drainage unless there is gross pleural infection, air is then drawn off with an artificial pneumothorax apparatus. If missiles are removed in the presence of empyema rib resection and closed drainage is usually employed.

thiazole-penicillin powder and the dead space obliterated with a few catgut sutures. After pleural toilet the chest is completely closed without drainage unless there is gross pleural infection, air is then drawn off with an artificial pneumothorax apparatus. If missiles are removed in the presence of empyema rib resection and closed drainage is usually employed.

**(B) Pleural Missiles**

A radiographic examination on the day of operation is an essential as the metal may change its lodging. Frequently these metal fragments are associated with empyema and because of this they should be removed as early as possible (note that of 27 diagnosed pleural missiles, 26 have been removed); if an empyema is present the pleural cavity is cleared out by clot clearance operation and the metal removed. Small empyema cavities are not drained but treated by the penicillin aspiration technique (d'Abreu, Litchfield and Scott-Thompson, 1944). Large cavities are drained by the closed method. If the pleura is clean or the site of simple hæmothorax the metal and fluid are removed and air drawn off by an artificial pneumothorax set after closure.

**(C) Mediastinal and Cardiac Missiles**

In no instance has the sternum been split: in one case the metal was seen lying deep to sternum in the pericardium. After exact pre-operative localisation a disc of sternum was trephined, the hole enlarged with Trotter's nibblers and under radiological screening in the theatre the metal was localised by needle and removed. For pericardial and most superior mediastinal missiles the approach had usually been extra-pleurally after resection of the appropriate costal-cartilage and rib, ligation and division of the internal mammary vessels followed by rib spreading; occasionally the exposure is increased by dividing another cartilage. No hesitation is felt about opening the pleura if such a procedure helps the approach and this is frequently done for the pericardial missiles: in such cases the pericardium is left open to drain into the pleural cavity where post-operative aspiration is readily done. By these methods shell fragments have been removed from the Thymus, from beneath the superior vena cava, from the vicinity of the aortic arch and from the pericardium; one particular interesting case was an Indian soldier whose foreign body lay within the lumen of the right subclavian vein which was sutured after its removal without the development of œdema of the arm.

Occasionally metal in the superior mediastinum has been removed through a low collar neck incision. Missiles in the posterior mediastinum are removed through the classical transpleural thoracotomy approach. They have been removed from para-œsophageal positions from the vertebral bodies and from alongside the great vessels.

**Cardiac missiles.**

Seven have been seen and three are in hospital at the moment. None has been removed successfully. Two operations have been done with two deaths as already described. Most of these patients have shown clinical cardiac enlargement and electro-cardiograph evidence of muscle damage: the enlargement slowly subsides under complete bed rest and our impression now is that removal should not be attempted at this level.

**(D) Metal in the Endo-Thoracic Fascia**

These are localised radiologically usually by placing a needle directly on to them. If the effusion around the missile is infected a thorough toilet is done and the wound closed completely by the penicillin instillation tube technique, drainage being reserved for the larger cavities. It is always important to resect fractured rib fragments which are common associates. Familiarity with the radiological appearances of extra-pleural effusions is a great help in the exact localisation of these oddly situated missiles. On four occasions the missile lay in front of the neck of a rib and costo-transversectomy was necessary to provide access for removal.

**SUMMARY**

1. The early complications of retained intra-thoracic missiles are, hæmoptysis, pleural empyema, and lung abscess, infected extra-pleural effusions, and the mental anxiety of the patient.

2. Removal of missiles of one c.m. or more is safer than leaving the missiles *in situ* and carries less risk of later morbidity.

3. In the last 719 chest casualties 137 have had missiles removed. Seventy-one were removed from the lung. There were two post-operative deaths due

partly at least to associated non-thoracic lesions. Twenty-six were removed from the pleura with no deaths. Seventeen were removed from the mediastinum with death in one instance following the extraction of a shell fragment embedded in the pericardium and in the left ventricular wall. One large fragment in the heart (inter-ventricular septum) was operated upon but not removed owing to the friable state of the myocardium: the patient died the next day. Twelve missiles were removed from the endo-thoracic fascia without a death.

4. The selection of the patients for operation is made on the site and size of the missile, after the early physiological derangements have been corrected and a very careful radiological assessment has been made.

5. The technique of the operative procedure and the post-operative management is briefly discussed.

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**CLOTTED HÆMOTHORAX**

by

Major W. F. NICHOLSON, RAMC

**Introduction**

The clotted, multilocular or "organising" hæmothorax is a condition which is sufficiently common to demand our attention. Though spontaneous absorption does occur slowly in some cases, in the majority infection is present and the neglected clotted hæmothorax is a common cause of empyema. The infection is often low grade in these cases, so that pus is slow to form; penicillin still further delays the onset of suppuration. But in many cases an empyema eventually is formed. Evacuation of the clot and local chemotherapy will frequently prevent an empyema from developing, especially if the operation is done in good time. It is therefore important that these patients should be evacuated to the Base as soon as they are fit to travel, if possible, not later than the tenth day. Once suppuration occurs, though surgery may still be of value in limiting the infection, it is unusual to avoid drainage of the pleural cavity.

**INCIDENCE**

There were 93 clotted or loculated cases in 1,027 consecutive hæmothoraces (9%). Though there were other small basal clots which were never confirmed by operation, these raised no special problem and have not been included.

**PATHOGENESIS**

Clotting is twice as frequent on the right as on the left side. There were 61 right and 32 left clotted hæmothoraces. Though there is a higher percentage

of fluid hæmothorax on the right, owing to the greater mortality in left-sided wounds, it is only 56% right to 44% left, so that there is a real increase in the incidence of clotting on the right side. We have been impressed with the association of clotting with thoraco-abdominal wounds on the right. It may be that it is only the greater tissue damage that favours clotting, but the most likely explanation is the low grade infection associated with liver wounds. Though it did not appear at first that infection favoured clotting, there is now no doubt that low grade infection is very common. In over three-quarters of the cases in which we have evacuated clot, organisms have been found in either the clot or fluid, or fibrin peeled away from the lung surface; the organism most frequently found is the staph. aureus. This is an organism which produces no fibrinolysin, so that it is not surprising to find it present in these cases. Low grade infection is therefore common in the clotted hæmothorax, not infrequently associated with a retained foreign body.

**MORBID ANATOMY**

There are two distinct types:—

- (a) The multilocular hæmothorax in which fibrin webs divide up the pleural cavity into many loculi, each containing a little liquid blood. Here aspiration is tedious and frequently unsatisfactory, moreover some loculi may be infected and others sterile, till later on the whole pleural cavity becomes infected.



- (b) The rarer type — a hæmatoma, in which the blood clots to form a solid clot usually in the postero-basal part of the pleural cavity; serum which separates from the clot floats to form a separate loculus in front.

#### DIAGNOSIS

This depends on a difficult or failed attempt at aspiration, both posteriorly and in the axilla. In the loculated type fluid may be tapped, but very soon ceases to flow; perhaps 20 to 30 c.c.s. is as much as can be aspirated at each site. The fibrin webs block the needle. Even with a wide-bore needle, though more fluid can be aspirated it is rare for the hæmothorax to be completely evacuated. Clots in the aspirated fluid are good evidence of other clots remaining in the pleural cavity. In the hæmatoma, aspiration is usually unsuccessful except for serous fluid from an anterior puncture. Sometimes the needle can be felt to impinge on a solid clot. X-rays of the loculated hæmothorax are so typical that they are readily recognised.

*Case report:*—This patient was wounded at El Alamein in Oct., entry wound in the neck in the right posterior triangle, the missile retained behind the lower end of the sternum. One month later, when he came to us, he had a loculated hæmothorax. He continued with low fever till the hæmothorax was evacuated. The X-rays show a typical loculated hæmothorax. No organisms grown from the clot or fluid in this case.

It is the solid clot which is more frequently missed. Here there is basal opacity, typically extending up in the posterior gutter so that it tails off above. This is frequently thought to be thickened pleura, or a thin layer of fluid; but irregular air spaces in the opacity are typical of clot. The pleura is not sufficiently thickened at this stage to cause such a dense opacity, which must be either due to fluid or clot. If no fluid can be aspirated, it must be clot.

*Case report:*— This officer was wounded in Feb 44, a perforating GSW on the right from the 6th space in the mid-axillary line to the 10th space in the scapular line. X-rays show a clotted hæmothorax — this was chiefly solid clot. Three aspirations, all difficult, yielded only a little fluid, and clots. Gr+ve bacilli and pus cells were present. Operation showed a solid hæmatoma. Evacuation of clot and decortication.

Fever to 100° is usual, and does not necessarily indicate that infection is present, though it is common enough.

#### TREATMENT

##### *Conservative*

There is no doubt that some clots are absorbed slowly; twelve of the larger and many small basal clots have been treated conservatively: but absorption of large clots is slow and usually leaves pleural thickening with limitation of movement. This is not surprising when we consider the frequency of low grade infection in such cases. The tragedy of conservative treatment when generally applied is that many cases will ultimately develop empyemata, at a stage when the chest wall is already "frozen" by thickened pleura. As Col. d'Abreu and his colleagues have stressed in a recent article, fibrin is very

excessive in these empyemata, which are often very loculated. Drainage is therefore difficult and may be impossible without breaking down some of the fibrinous septa.

##### *Operative measures*

Though penicillin may sterilise many of the loculi in a loculated hæmothorax, it does not always reach the centre of fibrin clots. These, therefore, remain a source of infection. It is therefore generally agreed, amongst surgeons, that the clots should be removed, Thoracotomy with evacuation of all clot and fluid greatly decreases the risk of an empyema developing. The controversy arises over the treatment of the empty pleural space, and here there are two policies. One is to close the chest, leaving penicillin in the dead space, repeating aspirations with penicillin replacement till the lung expands to obliterate the dead space. The other is a more radical operation, by which the lung is encouraged to expand immediately so that no dead space remains. This is decortication. At our Centre we have favoured decortication, because we have been impressed with the toughness of the fibrin lying on the visceral pleura. When this is stripped away, a normal thin shiny visceral pleura is displayed and the lung expands easily. Moreover, organisms are frequently grown from this fibrin "peel" even when they are not present in the clot or fluid.

*Case report:*— This man was wounded in May 44, GSW with entry over the left shoulder and the missile retained in the body of the 7th dorsal vertebra. Complete collapse of the left lung with an uninfected hæmothorax. Thoracotomy for removal of the missile two weeks after wounding; a decortication was done at the same time although the fibrin was not very thick on the lung surface. A pure growth of hæmolytic staph. aureus was obtained from the fibrin "peel". X-rays show the post-operative result, no empyema, and at Con. Depot six weeks later.

Thus, a more complete operation not only allows immediate lung expansion, but also removes more infected material. If a pulmonary foreign body has to be removed, or a broncho-pleural fistula requires repair, suturing of the lung is much more satisfactory after the fibrin has been stripped from its surface. When the operation has been completed, the lung is expanded by the anaesthetist and the chest is closed with temporary intercostal drainage for the first two or three days.

*Case reports:*— (1). Wounded end of Oct 44 by mortar, entry in 7th space left paravertebral line, a small foreign body retained in the lingula lobe. Four aspirations with penicillin replacement, getting increasingly difficult, before operation three weeks after wounding. Large basal hæmatoma (two pints) with an anterior collection of fluid and fibrin. Staph. aureus grown from blood clot, "peel" and fibrin clot, but not from the fluid. Decortication. Fever settled promptly. Con. Depot six weeks later.

(2) Wounded end of Sep 44, entry in right anterior axillary fold, a fragment being retained in the right posterior chest wall. Four small aspirations of a loculated partly clotted right hæmothorax, the fluid containing pus cells but sterile. Six weeks after wounding, thoracotomy. A loculated hæmothorax, with the lung adherent along the oblique fissure (site of entry) but elsewhere collapsed. Clot in the basal cavity and loculated fluid and clot in the upper.



Decortication and temporary drainage (four days). Though the clot and fluid were sterile, non-hæm. streptococci were grown from the "peel." X-rays show subsequent expansion of the lung, no empyema developed and fever settled very soon after operation. He remained well during two month's observation, when he was downgraded to Category B1.

One criticism of the method is that there is a theoretical danger of insufflating septic material into remote bronchioles when pressure is applied by the anaesthetist; we believe that this is not a real danger in most of these cases; the lungs are not wet, and are in no way comparable to the septic bronchiectasis of civilian practice. Routine post-operative bronchoscopy in a series of cases showed so little secretion that it was considered unnecessary.

Another criticism is that a wounded lung requires time to heal, *and it may be better to leave it collapsed until healing is complete.*

The experimental work of Montgomery suggests, on the contrary, that the process of repair in lung wounds will be quicker and more complete in the fully expanded lobe. The conditions which encourage healing in a tuberculous focus are not necessarily of equal value in war wounds.

Unfortunately in so many of these cases it is the lower lobe which bears the burden, even when the wound has been of the upper lobe alone. Often the upper lobe is expanded, but the hæmothorax has prevented the lower lobe from expanding. So that the healthy lobe remains collapsed till the clot is removed; but even with a wounded lobe, if it is collapsed, by the time the decortication is done — not usually till three to four weeks after wounding — the wound track will not be disrupted by the pressure necessary to expand the remaining lung. That this is true we have observed many times, when a waist-like constriction, corresponding with the healed wounds has appeared in a lobe which has otherwise expanded satisfactorily.

A further criticism is that to disturb the walls of an abscess cavity is bad surgery, and that to do so invites dissemination of the infection. It may be that here penicillin (both local and systemic) has enabled our patients to withstand our onslaughts; but there are certain features of the fibrin coat on the surface of the lung which are quite different from the walls of an abscess cavity. The fibrin settles on visceral pleura long before infection occurs — in every hæmothorax, infected or sterile, fibrin is deposited on the lung. As infection progresses (especially if fibrolyns are absent as in staph. aureus infection) more fibrin is deposited together with other inflammatory products. But in the majority of cases the pre-septic deposit of fibrin forms a barrier between the visceral pleura and the empyema cavity. This explains why in many cases it strips so easily from the lung with very little bleeding leaving a normal shiny visceral pleura beneath.

Finally, although decortication may expand the lung, it may leave pleural pockets where pus accumulates if an empyema forms. This is true: unless complete expansion occurs such pockets may remain. They are usually small and situated commonly at the apex, at the anterior costo-phrenic angle, and at the base. Even if one or all these pockets required drainage it is still true that the patient may be more fortunate than he would be waiting for spontaneous re-expansion to occur with

a total empyema. We drain the pleural cavity with intercostal drains at these three sites, so that if an empyema does form it is usually quite small. But in the majority of cases (30 in 47) an empyema has not formed after thoracotomy and decortication in the clotted hæmothorax.

*Case reports:—* This man was wounded on 20 July 44. Left thoraco-abdominal with wound of the stomach. One month later arrived at the Chest Centre with a clotted pyothorax. Rib resection, clot scooped out and water-sealed drainage. Pneumococcus only grown from the pus. Two weeks later there was no appreciable expansion of the atelectatic lung. Decortication was easy. Intercostal drainage in 4th space in front and posterior drain replaced. Streptococci grown from the peel. The lung expanded well, the anterior drain being removed after two months, when a sinogram showed no remaining cavity. There was still a posterior tube track, so that a small basal tube was required. General condition excellent. This is a case in which drainage was not avoided, but re-expansion accelerated.

(2) Wounded 12 Dec 44, entry 6th space anterior axillary line on the left, the fragment perforating the upper lobe, and lying in the posterior triangle of the neck on the left. Aspirated five times before arrival at the Chest Centre on 30 Dec. He now had a loculated pyothorax, with a pleural hernia into the neck. Thin pus was aspirated from the anterior loculus, yielding coliforms and diphtheroids. Thoracotomy on 6 Jan 45, evacuation of basal clot and anterior clot and pus. The upper lobe was adherent at the entry wound, otherwise the lung was quite flat. Rib fragments embedded in the upper lobe were removed. Easy decortication and complete expansion. Temporary drainage in front in the 2nd and 6th spaces, and behind in the 9th space. The front drains were removed on the fifth day and the posterior on the ninth, when the foreign body was removed from the neck.

Simple evacuation of clot and closure is successful in the basal clotted hæmothorax, but where a whole lung is collapsed there is great advantage in getting the upper lobe expanded as soon as possible. Return of the lung to full activity is thereby effected at a much earlier stage than can be attained with conservative treatment. As Colonel Churchill has written: "The change of the focus of attention from pleural space to lung stands as one of the important achievements of the military surgeon of World War II. The point of view that holds a lung injury to be progressing satisfactorily as long as pleural infection has not supervened is no longer tenable."

### Summary

(1) Nine per cent. of all hæmothoraces are clotted.

(2) Infection is common — often low grade. Seventy-five per cent. of clotted hæmothoraces were infected.

(3) There are two types — the multilocular, partly fluid; and the solid hæmatoma.

(4) The diagnosis is discussed.

(5) Evacuation of clot by thoracotomy and decortication is recommended for large clots.

(6) The arguments for and against decortication are reviewed.



# POST-OPERATIVE TREATMENT OF CHEST WOUNDS IN FORWARD AREAS

by

Capt. F. HODGKISS, NZMC

## Introduction

In the short time at my disposal I wish to speak about post-operative treatment of chest wounds in forward areas.

A successfully treated chest wound implies a soundly healed chest wall, a fully re-expanded lung, a dry uninfected pleura and normal respiratory function.

The actual surgical operation is but one incident in the chain of events leading to complete recovery. A successful operation may be ruined by inexperienced or inadequate post-operative treatment, and day to day observation and adjustment must be carried out to ensure a successful end result.

## Post-Operative

If the chest has been opened, gentle inflation of the lung by the anaesthetist as the chest is being closed at the end of the operation is helpful in reducing the size of the resulting pneumothorax. Or alternatively, aspirating air from the closed chest by inserting a needle into the second intercostal space in front, may be done.

On recovery from the anaesthetic and shock, if it be present, it is customary to nurse the patient in a sitting-up posture in bed. Though it may be uncomfortable for the first twenty-four hours, the patient soon finds that he can breathe better this way and becomes accustomed to the posture. Any blood in the pleural cavity then gravitates to the lowest part of the chest which is posteriorly, in the angle between the diaphragm and the posterior chest wall, and it is from this position that it is easiest to aspirate. In this position also the patient can be examined with a minimum of disturbance.

If a severe intrathoracic wound has been repaired the patient may suffer from breathlessness for the first twenty-four hours and require oxygen by a B.L.B. mask, though it is usual to find that he is in much better shape after his operation than before it. Morphine in doses of Grs.  $\frac{1}{8}$  to Grs.  $\frac{1}{4}$  may be required three or four times in the first twenty-four hours if in much pain.

After twenty-four hours, X-ray films P.A. and lateral should be taken with the patient in the sitting-up position to see the quantity of fluid, the amount of air, and the degree of re-expansion of the lung present. This cannot be done in an F.S.U. working with a Field Ambulance or F.D.S. as there is no X-ray apparatus available, and one must rely on physical signs which are often misleading, no matter how skilled the examiner. X-ray is available at a C.C.S.

There is practically always residual blood present in the chest ranging in quantity from three to thirty ounces or more, and varying volumes of air. This is better removed along with the air to allow the lung to re-expand as soon as possible, and aspiration can be commenced twenty-four hours after operation.

## Aspiration

Aspiration of fluid from a chest can be easy and painless to perform if a correct technique is mastered.

## Instruments

A 50 cc or 20 cc Record Syringe with a 3-inch needle of 2.1 mm bore is satisfactory.

A two-way tap which fits the needle and syringe is interposed between syringe and needle and about 9 inches of fine rubber tubing is fitted to the outlet stem of the tap and leads into a sterile bowl or measure to hold the fluid.

A 2 cc or 5 cc syringe fitted with a fine bore needle  $1\frac{1}{2}$  or 2 inches long is used to inject 2% local anaesthetic into the selected intercostal space. Novutex causes pain whilst injecting, planacaine or procaine does not.

The patient is sat forward in bed with three pillows in his lap for him to rest his arms over. If available P.A. and lateral X-ray films are examined to determine the position of the diaphragm and the level of the fluid and its relation to the ribs. The ribs are counted on the film and also on the chest itself beginning with the twelfth, and the exact site of puncture is determined. If there is any difficulty in obtaining fluid in the scapular line posteriorly, puncturing in the mid-axillary line at the same level as before is usually successful. It is best to take off as much fluid and air as possible, without air replacement, in a simple hæmothorax, and if the patient complains of discomfort or tightness in the chest, a few minutes pause in the operation eases this discomfort. Pain referred to the top of the shoulder may be caused by the exploring needle impinging on the diaphragm, whilst pain referred to the upper abdomen is caused by pressure of the needle on an intercostal nerve. The remedy is obvious.

## Penicillin

At the end of the aspiration, penicillin is injected into the pleural cavity. Different workers use varying amounts from 30,000 units to 60,000 units. I do not know as yet the optimum dose nor the optimum quantity of fluid in which to dissolve the penicillin.

One has found that a very small quantity, 5 minims of 10% silver nitrate injected into the pleural cavity provokes a greater fluid reaction in the pleura than the same quantity and the same strength of silver nitrate followed immediately by 12 ccs of normal saline.

One is inclined to think it is concentration rather than quantity of reagent (within limits) put into the pleura which determines the fluid reaction. Col. Bentley's work suggests that it is the quantity of diluent introduced into the pleura which determines the fluid reaction. As our object is to get a dry pleura and re-expanded lung as soon as possible, aspiration every second day is usually necessary.

The patient should be encouraged and shown how to keep his spine straight and to use the affected side of his chest. Much of this can be done in the early days of his treatment.

## Failure aspirate:

The common cause of failure to aspirate successfully is that the chest is needled too low, and in

the absence of X-ray films, it is better to try the 8th or 7th intercostal space rather than the 9th, as in the majority of cases of hæmothorax the diaphragm on the affected side is raised.

### Breathlessness and Cyanosis

If breathlessness or cyanosis becomes obvious, search must be made for the cause. Some patients show marked cyanosis when taking sulphonamides in full doses, but it is necessary to exclude other causes before blaming the drug. The development of a tension pneumothorax, paradoxical breathing, a sudden accumulation of fluid in the chest, the development of an aspiration pneumonia on the contra-lateral side, or a massive atelectasis on the injured side will produce such symptoms.

These causes can all be determined by a clinical examination and treated accordingly.

### Atelectasis

The incidence of pulmonary atelectasis occurring during the course of treatment of chest wounds in this theatre of war as quoted by other observers, d'Abreau Litchfield & Hodson, is high, and my own cases show a similar high incidence. Abdominal cases also are exhibiting this troublesome post-operative phenomenon in a disconcerting frequency.

On casting round for a cause, one is struck by the prevalence of catarrh of the upper respiratory tract and the bronchial tree, even in the summer months, and more so in the winter months in Italy.

On examination of the sputum mugs in the ward, one finds tenacious, mucoid sputum produced by other as well as chest cases.

It is reasonable to suppose that such secretions are retained in the bronchial tree during the period of anaesthesia, causing bronchial obstruction with consequent atelectasis. In many cases the patient is too long under the influence of the anaesthetic after operation.

To attempt to combat this atelectasis, the anaesthetic used should be one from which the patient recovers very quickly, and he should be partly awake by the time he returns to the ward.

The passage of a long gum-elastic catheter into the bronchial tree and suction applied to aspirate excess secretion and blood is a good practice at the end of the operation.

The anaesthetic of choice for chest surgery is cyclo propane as this is non-irritating, allows the use of a high oxygen percentage, there is quiet respiration and the patient recovers quickly from the anaesthetic. Cyclo-propane is not available in an F.S.U. or C.C.S. in forward areas.

### Movement

Tight bandaging of upper abdomen and chest restricts movements of diaphragm and ribs, and may lead to a stasis of secretions in the bronchi of the lower lobe. The day after operation movement of the patient should be commenced. The back-rest and supporting pillows are removed from the bed and the patient is laid gently down in bed on his side, with his affected side uppermost and his head resting on one pillow. After ten minutes in this position, he is rolled gently over to lie on the opposite side for a similar period, then he is gently raised back into his sitting-up position. This manoeuvre can be done twice the first day, later three times a

day and for longer periods. Sometimes the amount of sputum coughed up during and after this movement is quite considerable, but even if no sputum is coughed up at first, it is worth while persisting with this posturing. If a definite atelectasis is present, persistent posturing for longer periods is indicated to allow the affected bronchus to drain into the main bronchus.

### Expectorant

If the sputum is tenacious and causes the patient great distress in trying to expectorate, a simple expectorant of Sod. Chlor. Grs. X, Sod. Bic. Grs. XX, Chlorof: Water  $\frac{1}{2}$  oz. taken in half-a-tumbler of hot water, or ammon. carb. Grs. X taken in milk four times daily makes matters easier for him.

If pain, due to injury of the chest wall, is preventing effective coughing, this may be alleviated by local injection of the intercostal nerves supplying the affected area.

Also small doses of morphine Grs. 1/12 or Gr. 1/8 are effective if there is pain in the region of the sternum. These doses do not depress the cough reflex.

### Infection of the pleura

This must be regarded as a serious complication of a chest wound. Intra-pleural penicillin therapy appears to be of value in this condition. If the fluid in the pleural cavity becomes infected, aspiration must be persistent to reduce toxicity and to reduce the quantity of fluid present to a minimum, in order to allow the lung to re-expand as much as possible so that a localised rather than a total empyema results. Rib resection and drainage at this stage is dangerous and is contra-indicated.

Frequent and thorough aspiration at this period usually results in a clinical improvement in the patient, so that he can be evacuated to a chest centre or general hospital where drainage can be done at the appropriate time. If, however, the patient remains very toxic in spite of repeated aspirations, or if he develops a broncho-pleural fistula, then drainage must be done at once. A persistent cough with copious blood-stained sputum and breathlessness in these cases usually indicates the presence of a broncho-pleural fistula.

### Insertion of intercostal catheter

A size 28 Malecot catheter is introduced at the appropriate site by means of a thoracic trocar and cannula using local anaesthetic and attached to an underwater drain so that pus and air can drain continuously from the chest, and the intra-pleural pressure will tend to become less than atmospheric and will encourage the lung to re-expand. This will necessitate keeping the man in a forward area longer than he would otherwise stay.

### Conservative surgery in forward areas

In forward areas the aim of the surgeon in dealing with chest wounds is to make the patient fit for transport in the shortest time possible, consequently his surgery must be conservative. A patient with a major thoracic wound is rarely fit to travel to a base hospital in time to have delayed primary suturing done to large chest wall injuries, so this can quite well be done in a forward unit, provided that the unit is not pressed for beds and no big action is in progress.



## Transport

The evacuation of chest cases to a special centre where adequate facilities exist for continuing treatment, dealing with the complications, and making the man fit again, has its problems. The earlier the case arrives at such a centre, the better, but there are a few cases of a major thoracic wound which are well enough in less than seven to ten days to bear well, long ambulance journeys.

Air evacuation of a patient with a pneumothorax is dangerous if for any reason the plane has to climb to a higher altitude than usual, as the pneumothorax becomes larger, and the patient suffers from dyspepsia.

When lines of evacuation become long and difficult, the question arises: should the patient travel to the chest centre or should the chest centre move up nearer the patient? There is much to recommend the latter.

## THORACIC TRAUMA

by

Major MAXWELL TELLING, RAMC

"The point of view that holds a chest injury to be progressing satisfactorily as long as pleural infection has not developed is no longer tenable. Every consideration is now given to the restoration of full lung function. The change of the focus of attention from the pleural space to the lung stands as one of the important achievements of the military surgeon in this war." — Colonel Edward D. Churchill, Surgical Consultant to the U.S. Army, Mediterranean Theatre.

### Thoracic Trauma in Forward Units

Reception must be handled by an experienced officer, who for obvious reasons may be a medical specialist. So far as the actual wounds are concerned, the majority present no problem: excision is the rule, and the wisest rule. Certain wounds, however, do not require excision: the clean T/T wound usually due to a rifle, revolver, or M.G., bullet, with clean drilled small neat holes of entry and exit and no bony trauma; and the entry only wound of similar aspect, usually due to a small piece of metal, where pleural penetration has occurred.

These will heal rapidly with local penicillin or sulphanilamide powder and a dry dressing. The lung injury is a pulmonary hæmatoma with effusion of varying size. Needless to say, these patients must be watched for signs of hæmorrhage, and X-rayed if necessary. Here I may say that it is desirable but not essential to X-ray every patient before operation.

If surgical emphysema of more than 2" radius complicates such wounds, excision is essential.

A man aged 38 with a clean T/T wound of left chest arrived at the C.C.S. 28 hours after injury; there had been slight hæmoptysis, his general condition was good, but surgical emphysema extended above the clavicle. He reached the theatre an hour later, where a small S.V.G. dressing was firmly applied. A skiagram showed a small left pneumothorax with a tiny effusion. Twenty-four hours later, I was urgently called to see the man, who was intensely distressed and dyspnoëic, with surgical emphysema down to his iliac crests and up to his zygomata. An hour later exploration of the wound revealed a "minute central perforation of the anterior wall of the body of the 2nd rib: section of rib resected revealing tiny hole in pleura, both layers

being adherent. Repair not possible. S.V.G. dressing only. Bad prognosis." After an extremely stormy passage the man recovered. In a similar case, the surgeon explored the wound, closed the pleura, and post-operative progress was peaceful. These penetrating wounds of ribs without any bony destruction may be tricky, and should always be explored, both to control surgical emphysema and to remove any indriven bone fragments: Indriven bone fragments are extremely dangerous causes of hæmorrhage and sepsis, and may cause more trouble later on than a metallic F.B.

The distinction between thoracic and thoraco-abdominal wounds may be very difficult: the abdominal rigidity which an uncomplicated hæmothorax may produce has to be seen to be believed. Visual reconstruction of the position of the patient when hit and repeated examination in the ward, are essential. The diaphragmatic cupola may be hit at the top of its thoracic excursion. Shoulder tip pain is not very helpful. Generally, in a thoracic wound, the abdominal rigidity is unilateral or limited to one upper quadrant, or is not quite "right" for a wound of belly, or may be abolished by morphia gr  $\frac{1}{4}$ . Continuity of observation by the same observer is essential, as the signs in a belly wound progress as a rule more rapidly than in a thoracic: radiography is a most valuable and essential aid.

If I seem to have laboured this point, it is because the average surgeon is happier in the abdomen than in the chest, because a negative laparotomy is better than a missed abdominal wound, because abdominal mischief is more deadly than thoracic (43%:16% in last war, 13½%:8% in M.E.F., Wiles, 1944), because an unnecessary laparotomy may kill the patient, and because the trans-thoracic approach is often inadequate, while the chest lesion may be tidied up from the abdominal side. Hence I stress the value of adequate pre-operative examination in these patients. Finally, sucking chest wounds take priority over abdominal wounds.

### Cardiac Injuries

These are rare, but very easily missed.

Cardiac tamponade may be recognised by extreme and progressive collapse, a falling arterial and rising

venous pressure, pulsus, paradoxicus, venous distension and cyanosis in head, neck, and upper limbs, reduction in quality of the heart sounds: cerebral symptoms and even coma may appear.

A clinical point not generally known, and most ably brought out by Paul Wood and W. F. Nicholson at the recent Conference of Physicians, is that a "near miss" of heart and great vessels by an F.B. may cause pericarditis and effusion with their attendant signs.

So much for the thoracic problems of forward surgery.

### Hæmothorax

It is essential to remember that a hæmothorax may often accompany fractured ribs and cardiac wounds, as well as blast and other injuries to the chest although no wound is visible. But by far the largest number are due to penetrating wounds. There is a small but important group of "missed" hæmothoraces, in which the possibility of thoracic penetration has never been considered or has been forgotten in the stress of battle surgery or evacuation: it is associated with wounds of the abdomen, the costal margin, or of the lumbar region.

The uncomplicated hæmothorax is reflected clinically in two stages. (1) The reaction to injury, lasting 24 to 60 hours; characterised by acute onset, pain, dyspnœa, apprehension, a varying degree of hæmorrhage and of shock, fever rising in 24 hours from subnormal to 102-103 degrees F. with a corresponding rise in pulse rate. (2) The stage of quiescence, associated with physiological compensation and a lessening of the acute mental and physical distress. It is quite usual for these patients to have a sustained fever of say 100-102 degrees F. for the first two to five days after injury, followed by an evening rise to 99 or 100 degrees F. for a further week; the pulse rate tends to settle earlier than the temperature. Less commonly fever may persist for more than two weeks in the absence of infection.

*Treatment.* This may be summed up in three words—efficient early aspiration. Certain objections to this procedure have been raised: the risk of introducing sepsis, of restarting bleeding from the wound, or of causing a new hæmorrhage, and the fact that some effusions will absorb completely if left alone.

It is quite impossible to tell which effusions will absorb uneventfully and how quickly; sepsis or hæmorrhage due to actual needling is a reflection upon the operator and not upon the method; there is a negligible danger of restarting bleeding from the wound. It is generally agreed that clotting occurs within six to twelve hours, so the surgeon may safely empty the chest during the initial operation and perhaps thereby obviate any further tapping.

*Further.* The return to normal function of the lung, diaphragm, and chest wall, is enormously accelerated, and the time spent in hospital and convalescence greatly curtailed with consequent conservation of man power, etc. If the fluid is not removed, it may clot. Five to ten percent will clot anyway. (W.F.N.). If it does not clot the fluid may become infected, for it is an excellent culture medium.

Finally, what happens if the fluid is left and does not clot?

Fibrin is always deposited on the lung and pleura. Hæmothorax fluid is an irritant causing thickening of parietal and visceral pleura if left,

The slow absorption of fluid leads to inspissation which renders further absorption even more difficult. The blood is slowly replaced by fluid rich in cholesterol crystals; the shaggy walls of the cyst may calcify while the fluid is still present: if sepsis develops in the years following, treatment is difficult. (T. Edwards, 1943b.)

The lung and chest wall are immobilised (quite unnecessarily) for a varying period and in time the lung, chest wall, and absorbed hæmothorax, may be bound together in an almost iron-hard mass of fibrous tissue, which may calcify or even ossify in the years to come. The so-called frozen chest in its most extreme form.

An infected hæmothorax is an evil thing. The sepsis rate varies with different authors; Ryle (quoted by T. Edwards, 1943b) gives 80% for the last war; Tudor Edwards (1943a) in 204 patients found 11.3% with closed, and 22% with penetrating, injuries which became infected. Of 434 hæmothoraces from 1.4.44-30.9.44, 15½% became infected (W.F.N.) Tudor Edwards also found that the earlier the hæmothoraces are aspirated, the fewer become infected.

The commonest cause of invaliding in chest injuries in the last war was chronic empyema; Clifford Hoyle (1940) found that 5% of those whose effusions remained sterile were permanently invalided, 33% became infected, and of this 33% half died. Conservatism was then in vogue.

Infection becomes evident early or late: from the fourth to the seventh day is a common time. It should be suspected when there is an unexpected rise in pulse rate or temperature which is *sustained*, or a decline in condition, return of dyspnœa, or when the temperature keeps rising again after each aspiration. Low-grade infection may declare itself in the second or third weeks by persistent irregular fever and lack of expected progress in the patient. A white cell count is sometimes valuable. The patient does not always look ill or toxic.

### Technique of Aspiration

This *should* be a simple and painless procedure.

1. Explain to the patient what you are going to do, and why.
2. A separate room is desirable, but not always available except in Chest Centres. In the Ward use screens. Preliminary morphia is rarely needed.
3. The patient must be sitting up, or at least well propped up with back-rest and pillows.
4. Physical signs. There is always reduced movement, tactile vocal fremitus, impaired percussion note, weak or absent breath sounds, and often stony dullness. There may be much more fluid present than the signs and skiagram indicate.

*Good breath sounds, even bronchial breathing, may be heard through a layer of fluid.*

Clinically it is quite impossible to differentiate between residual fluid or mere pleural thickening, and X-ray may not help. Needling is essential.

5. The site or sites of election should be decided beforehand by examination and/or skiagram in two planes. The site should be memorised or marked; the tendency is to go too low. This is important because in many patients the diaphragm on the injured side is raised, and fibrinous sludge collects in the costophrenic gutter,



6. The technique of local anaesthesia is of paramount importance. Novutox causes pain locally, so I always use 2% procaine. Potain's aspirator with an ordinary blood transfusion needle attached is most efficient; otherwise a Rotanda syringe or one with a two-way tap is essential. A stout 3" needle is often required.

7. Begin (1) at initial operation, (2) 24-36 hours later, (3) or 24-48 hours after wounding, (3) and afterwards daily.

8. The quantity aspirated varies from one to three pints at a session, and the time from 10-45 minutes. There are also many variables which I need not stress here.

I would like to condemn the practice of air replacement. It is unnecessary, and quite inaccurate unless controlled manometrically, because no one can foretell the mediastinal vagaries of any particular patient. Apical collapse is inevitably ensured; all possibility of the upper lobe becoming adherent is temporarily removed, and lung expansion effectively delayed. Should infection supervene, it is sad to think that what might have been a basal empyema is now a total pyopneumothorax.

Only on rare occasions, such as the outlining or localisation of fluid pockets in a clotted or loculated haemothorax, would I advocate air replacement, and then 50-100 c.c.s. is enough. Another point, which is often forgotten by those who stress the risk of introducing sepsis with the needle, is that both lung and pleura have already been penetrated by a missile, a potential source of infection which itself commands aspiration, in view of the known empyema rate of 15-35%. Furthermore the clotting rate is 5-10% (W.F.N.).

Serial radiological control is essential in all aspiration work owing to the vagaries of the physical signs.

The specimen should always be sent for cytology and culture (anaerobic as well if necessary), and the results recorded in the notes. The normal appearance of the fluid changes from frank blood to clear yellow serous fluid, as absorption progresses; sometimes it becomes thick, tarry and inspissated. Blood is a pleural irritant, and in the pleural cavity is diluted by the fluid whose secretion it provokes. At first the Hb may be as high as 70% and R.B.C. 3,000,000; the R.B.C. and polymorphs rapidly diminish in number and later lymphocytes and macrophages dominate the picture: in the second or third week the latter are filled with pigment.

An infected fluid may be recognised by the smell, the colour which ranges from dark purple to brown, turbidity, and change in consistency. Microscopically the pus cells are sharply increased in number, and smear and culture may yield an organism.

It is a wise policy to leave 30,000 units of penicillin in 40-50 c.c.s. of saline in the chest after each aspiration. I have never seen any reaction to this.

It is not generally recognised how greatly Pentothal (0.5-1.0 grammes) facilitates multiple aspirations to establish the presence of loculation or to find an elusive pocket. An anaesthetist is essential. The patient should be arranged in the desired position, sitting up, leaning on an adjustable instrument tray or pillows on a heart table: in this position, and only when the operator is completely ready, the injection is made.

That there is a slight risk in aspiration I do not deny. The possibility of infection has already been mentioned, and pleural shock is a familiar boggy.

Aspiration may cause haemorrhage by disturbing the equilibrium between lung movement, intrapleural pressure, and wound repair. In 1027 patients this occurred 4 times in 3 years—0.38% (W.F.N.): three died. All had infected haemothoraces, three following penetrating wounds and one a crush injury; two were clotted. The intervals between aspiration and collapse were eight hours, a few minutes four hours, and two hours. All had had one or two uneventful earlier aspirations.

The first collapsed and died eight hours after aspiration of 600 c.c.s. on the sixth day after injury: bright blood, the source of which was not found, was obtained from the second interspace.

The second had suture of wounds and aspiration of 700 c.c.s. of infected blood under pentothal on the tenth day. He collapsed and died four hours later. Haemorrhage was parietal in origin, probably from the a zygous vein.

The third was aspirated on the ninth day, 850 c.c.s. being removed. Severe coughing and collapse occurred at once; and needling showed fresh blood in the second intercostal space. After transfusion and further aspirations thoracotomy was done, and the seventh intercostal artery was ligated where the M.F.B. lay. Recovery was uneventful.

The fourth man was very interesting. On the sixth day he had wound suture and aspiration of 900 c.c.s. of blood and much air; two hours later he sprang a tension haemopneumothorax, which was relieved by aspiration and a fine water-sealed intercostal tube. Between the sixth and seventeenth day he had two moderate sized aspirations and it was obvious that the haemothorax had clotted. On the 21st day he was bleeding again, so a rapid thoracotomy was done, revealing torrential haemorrhage from the hilum of the left upper lobe, which was firmly adherent to the chest wall. Control of the haemorrhage was impossible, and he died on the table.

Subsequent dissection revealed that the M.F.B. lay in close relation to the hilar vessels of the left upper lobe, and that the only way of saving the man's life would have been forcibly to free the upper lobe, which was surprisingly adherent considering that only fourteen days earlier there had been a tension-pneumothorax, and do lobectomy.

Certain facts emerge from these case-histories. The presence of sepsis in all four: the rapidity with which collapse and death may occur, and the danger of the damaged artery and the M.F.B. being in close relationship or actually contiguous.

It seems reasonable to explain the haemorrhage in the first two patients by a change in intrathoracic equilibrium and disruption of wound repair. The last two patients present an old problem in surgery; and it hardly seems fair to blame the aspiration for their death.

In the same series secondary haemorrhage occurred four times; thrice on the eleventh and once on the thirteenth day: an incidence of 0.38%. Three patients had penetrating wounds and three of whom two died, had infected haemothoraces. The bleeding was parietal in one, pulmonary in one, and probably pulmonary in two, patients.



One man with a tangential non-penetrating wound, whose skiagram was clear on the fifth day, sprang a small bloody effusion on the eleventh day: recovery was uneventful.

The second produced a tension-hæmopneumothorax on the thirteenth day, eight days after the second aspiration of infected blood. Despite intercostal drainage he died. The bleeding was probably pulmonary.

The third had a hæmatoma with retained F.B. in the right upper lobe and no effusion; on the eleventh day he developed an effusion, presumably from the lung wound. He recovered uneventfully.

The fourth had 1000 c.c.s. of infected blood aspirated on the eighth day, and 10 c.c.s. of pus on the eleventh day. Twelve hours later he collapsed and died. Autopsy showed a large fresh hæmatoma and a lacerated lung, which was presumably the source of the bleeding.

An officer with extensive bilateral cavitating tuberculosis, who died from pulmonary hæmorrhage, is excluded from this series.

### Blood Transfusion

The value of this is obvious, but it is not generally appreciated how much a hæmothorax may deplete the blood (Hb60-70%). I always transfuse if the Hb (Haldane) is under 80% or the hæmatocrit under 40%. The best technique is the copper sulphate series, for the plasma proteins can be estimated at the same time.

Severe injury, even in healthy people, is followed by a large breakdown of protein tissue—the "toxic destruction of protein" (Cuthbertson, 1942). This protein loss is greatly increased by exudates such as occur in empyemata and burns. The American Empyema Commission in 1918 studied the toxic destruction of protein by analysing the nitrogen excretion in the urine, and demonstrated the tremendous tissue protein depletion so beautifully and successfully that it was promptly forgotten for nearly 20 years!

Cannon, Chase and Wissler (1943) showed that in hypoproteinæmic animals the immunological response, as measured by antibody production, was only one-third to one-fifth of that in healthy animals.

The vital importance of a high-protein, high-vitamin diet, begun immediately after operation, needs no further emphasis. The first holding unit where good laboratory assistance is available should "top up" the patient.

Two further points may be mentioned. In the presence of sepsis the globulin fraction is often increased; the albumen fraction is depleted by the coexistent anorexia and malnutrition: as a result the plasma protein total may appear normal, especially if this change in the A:G ratio is further accentuated by concentration due to dehydration. (Elman, Lischer, 1943.)

### Pulmonary Contusion

This is associated with direct blast, or violence therefrom, or with wounds of the chest wall, perhaps with fractured ribs or scapula. In 1,100 admissions from 1.4.44 to 30.9.44, 139 patients had pulmonary contusion (W.F.N.).

Pathologically there is more or less localised interstitial and intra-alveolar hæmorrhage, occasionally scattered, with a varying degree of atelectasis which is usually patchy and slight. Sometimes infection from the respiratory tract develops.

The physical signs are hæmoptysis, cough, sputum (which is bloody and mucoid or purulent), and pleurisy causing local pain. The temperature usually settles in a few days, the pulse and respiration rates being little raised. More severely wounded patients may be cyanosed, shocked and dyspnoic. Reduced movement, local rales, and occasionally a friction rub are evident. The skiagram shows patchy opacity usually confined to the site of the trauma; but sometimes, and in more severe examples, the radiological signs are far more extensive than the physical.

It is evident that pulmonary contusion resembles the less severe degrees of blast lung; this is also met. The moving of severely blasted patients should be cautiously undertaken as any premature disturbance may start more bleeding.

The prognosis is good and treatment is by sitting up the patient, sedation P.R.N. and chemotherapy.

### Dry Pneumothorax

This is often found as a result of (1) blast and violence; (2) Chest wall wounds; (3) Small penetrating wounds. (F.B. may remain in the lung.)

Local wound toilet, a short course of chemotherapy, and early breathing exercises, comprise the necessary treatment.

### Pulmonary Hæmatoma

This is an interesting lung injury, classically seen in patients with T/T wounds with clean wounds of entrance, or penetrating E/O wounds of lung. Pulmonary contusion is often present. Hæmothorax is a frequent sequelæ, but I am only concerned today with the pure lesion.

Pathologically there is frank trauma of the lung; a varying amount of lung tissue is actually destroyed along the course of the missile track, so that a potential or actual cavity is formed, roughly cylindrical in shape. The lung surrounding the track is the seat of hæmorrhage, tearing and bruising, while the track itself is filled with extravasated blood, and the F.B. may lie at the end of it. The degree of atelectasis present varies, but is usually not large.

Clinically there is hæmoptysis, often considerable, or actual clots may be raised; cough, pain, surgical emphysema and fever are constant. The patient may be quite ill for a few days, dyspnoic and cyanosed. Locally the physical signs are reduction of movement and air entry, friction, impaired percussion note and rales.

Radiologically there is irregular opacity surrounding the missile track, which is roughly circular in the postero-anterior view and cigar-shaped in the lateral. The centre of the opacity may be relatively or completely clear, depending upon the extent to which the air-containing missile track has been filled with blood. (This track may easily be felt at operation.) The resemblance to lung abscess may be close.

The treatment is essentially the same as in contusion. The prognosis is good, allowing for possible complications from the F.B.

Both pulmonary contusion and hæmatoma may break down into an abscess with the usual signs. Is best treated by postural drainage, chemotherapy or penicillin, rarely by surgery. The abscess usually settles down uneventfully although the F.B. may have to be removed later.



## Convalescence and Rehabilitation

The object is to restore the lungs, chest wall and diaphragm to full and normal function, and to curtail the time off duty. The co-operation and confidence of the patient must be won at the outset, because the first effect of breathing exercises is to increase the pain of movement and of deep breathing, which characterises all chest wounds and which has depressed the patient from the moment he was wounded. A good physiotherapist with a strong personality is essential, and if a little sex-appeal is included, the result is a willing and enthusiastic class!

If breathing exercises are begun too early, they may cause undue pain, recurrence of fever or of effusion which may be clear or bloody and is due to tearing of adhesions.

1. Uncomplicated hæmo- or pneumothorax.—After temperature normal, 48 hours. Keep in bed 2-3 days before up.

2. Infected hæmothorax.—48 hours after drainage is satisfactorily established (or as soon as patient is fit).

3. Clean thoracotomy.—12-18 days after operation (needle and X-ray control essential). Temperature must have settled.

4. Thoracotomy for infected hæmothorax.—As soon as patient is fit.

5. Drainage of pyopneumothorax.—As in 2.

6. Medical empyema.—24-48 hours after operation.

7. Pulmonary contusion.—Very early. As soon as clinical signs and X-ray allow.

8. Pulmonary atelectasis.—As soon as recognised. Tell patient to cough and breathe himself all day.

9. Pulmonary hæmatoma.—As in 7.

10. Larger chest wall wounds.—10-15 days. As soon as wound allows. Usually up patients to up class for short course. Massage to scar.

The value of good nursing, occupational therapy, and fresh air, need no emphasis. The final assessment of category should be made by the Convalescent Depot Staff, who have directed the later rehabilitation of the patient. Temporary downgrading is frequently necessary, for it may take several months before the residual pain and dyspnoea on exertion disappear; very few patients with uninjured hæmothoraces need be sent to U.K.

Before I finish, I would like to say how grateful I am to my recent colleague, Major Frank Nicholson, who has given me free access to his figures and notes; and to Brigadier Edwards for according a physician the honour of addressing you.

In conclusion, Gentlemen, may I quote a line from a wise old physician, Sir Thomas Clifford Allbutt—"I would remind you again how large and various was the experience of the battlefield, and how fertile the blood of warriors in rearing good surgeons."

## Summary

The causes, physical signs, and clinical behaviour, of traumatic hæmothorax have been discussed. The treatment of uncomplicated hæmothorax is efficient early aspiration. The objections to, and risks of, aspiration have been set forth, and the practice of air replacement condemned. The irreparable

damage to the thoracic mechanism caused by leaving the fluid *in situ*, the risk of infection and its attendant evils, and the correct technique of aspiration have been emphasised.

The incidence of secondary hæmorrhage and of hæmorrhage due to aspiration have both been the same—0.38%—in 1027 patients; five of the eight patients died, and six were infected.

Adequate early transfusion with blood, or plasma when sepsis is extensive, is valuable. The causes, clinical and radiological aspects and treatment, of pulmonary contusion and hæmatoma have been elaborated. Breathing exercises are most valuable: the risks of starting physiotherapy too soon have been mentioned, and the value of good nursing is again stressed.

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## Discussion

### Major-General Hartgill

I have heard yesterday, and again today, references to radiology at the forward advanced surgical centres. As you know we have X-rays set up at C.C.Ss, but not with Field Dressing Stations of Field Surgical Units. When my committee was delving into this organisation at the War Office we took the advice of the Consulting Surgeon and the Consulting Radiologist. There was much discussion as to whether we should have radiology available at the advanced surgical Centres. For many reasons, which I cannot go into now, it was decided not to have them.

It is evident now that there is a demand for forward X-rays. I have been aware of that for some considerable time. My view of it was that big X-ray equipment is too cumbersome to get forward to many of the places where Field Surgical Units are located. I have asked our Adviser in Radiology about this, and he has devised a small and simpler apparatus; we are proposing to get it on a jeep with a trailer so that it will be available for use in difficult terrain such as the Appenines and the Burma jungles.

### Colonel E. D. Churchill, MTOUSA

I can assure you General Hartgill that this theatre has every reason to be proud of the work that has been done by the surgeons who have treated so efficiently wounds of the thorax. I don't know that we quite appreciate the problems that confronted the thoracic surgeon at the beginning of this war. In the reports from the last war there were no broad principles laid down as to the management of thoracic wounds. That is evident from one of the most heated discussions of the last war which concerned itself almost entirely with the question of whether differential pressure anaesthesia was desirable or

necessary. The X-ray was then in its infancy. Many of the X-ray examinations in the first part of the war were made on glass plates. X-ray specialists became preoccupied with elaborate methods of localising foreign bodies so that the surgeon could remove the missile through a key-hole incision. That was the state of affairs in the subject that Col. d'Abreu has so well covered. The influenza epidemic of 1918 with its terrific wake of empyema detracted our attention from the problems of military surgery, and much was lost that might have been revealed by a careful analysis of records of the wounded. Attention soon veered round to the management of chronic empyema in the period subsequent to the war. Between the wars it has been our experience that chest trauma is largely confined to low velocity missiles and to stabbings. That type of wound has nothing in common with what is encountered on the battlefield. Then again, in the past 25 years thoracic surgeons have been preoccupied with the development of the more elective type of surgery. We started into this war with a collection of techniques with little precedent on their use in military surgery. Surgeons have had to work out the timing of and the application of these techniques. These papers today show you that this theatre at least has its own standards and methods, in which there is almost complete agreement. I would like to point out that our surgeons have over-thrown certain very basically fixed ideas. If one principle came out of the empyema epidemic in 1918 it was that the duty of the surgeon was to postpone interference until an empyema was localised. Now the thoracic surgeons do not hesitate to open an infected hæmothorax which may be partially localised, and convert it into a generalised empyema in order to bring about quicker healing with a normally expanded lung.

This is a complete reversal of one of our old precepts of the management of empyema. One other thing—in the past 25 years progress in thoracic surgery the surgeon has been very helpfully encouraged by the physician far more experienced in thoracic disease than he. The physician has had to start from scratch in military surgery, as it was not included in his field of learning. I am delighted to see such a physician with us today. Unfortunately we have few physicians of Major Telling's experience and many of these problems have been met by the surgeon alone without having this very helpful support. So I am really very proud, and I hope you are, Sir, of the accomplishments of the thoracic surgeons in this theatre.

*Colonel Sanger, MCAUS*

I think that every missile should be removed, as one will go after it eventually. Perhaps we go for them too early, before hæmatoma has subsided.

Regarding aspiration of the chest. We have a simple way of doing it, using a vacuum bottle which we make in our own kitchen.

Colonel Sanger then described this technique and ended his remarks by saying that all American thoracic surgeons in this theatre are certainly in agreement with the papers heard this afternoon.

*Major-General Hartgill*

I for one have acquired a great deal of interesting knowledge this afternoon, which I didn't possess before, and I fully endorse Colonel Churchill's remarks as to the high talent of the chest surgeons in this theatre.

On your behalf I would like to thank the speakers at this session for their very excellent papers.



Wednesday, 14<sup>th</sup> February 1945

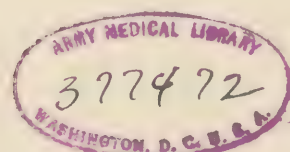
**Subject:**  
**ABDOMINAL TRAUMA**

*Presiding:*

Colonel Churchill Consulting Surgeon,  
*Mediterranean Theatre of Operations, United States Army*

Brigadier Edwards

As some of you know. I invited Sir Alfred Webb-Johnson, President of the Royal College of Surgeons, to this meeting. He writes that he regrets very much he cannot be here with us, but sends to all of you a message of admiration of the work done in this theatre, and all good wishes for the work to come. This morning, abdominal trauma is our subject, and Colonel Edward D. Churchill has kindly consented to take the chair.







# THE DIAGNOSIS OF ABDOMINAL TRAUMA IN WARFARE

by

Major C. G. ROB, M.C., RAMC

An unnecessary laparotomy is commonly performed in warfare. Major-General Oglivie records that of 247 laparotomies performed in the Western Desert, 42 had no internal abdominal lesion with a mortality of 24%; and 37 had a lesion of the liver or kidney only with a mortality of 27%. While some of these latter required abdominal exploration for the control of hæmorrhage, I would emphasise that no laparotomy was necessary in the majority; therefore approximately 70 of these 247 cases had an unnecessary abdominal operation and of these 70, 20 died. Later this morning Lt.-Col. Stead will give you the corresponding figures for this command, and you will see that the incidence of unnecessary laparotomy is still great. The high mortality for an abdominal exploration in the battle casualty makes a full clinical examination essential, and the abdomen should never be opened until a sound diagnosis has been made.

This paper is based on 162 admissions to an Advanced Surgical Centre, all of which showed marked and definite clinical abdominal symptoms and signs, and all had been diagnosed as a penetrating wound of the abdomen by a Medical Officer.

## ANALYSIS OF 162 CASES WITH DEFINITE ABDOMINAL SYMPTOMS AND SIGNS

I. LAPAROTOMY PERFORMED - - - -	111
(Deaths 39)	
(a) <i>Necessary</i> : (Wounds of the hollow viscera or wounds of the solid viscera in which hæmorrhage necessitated laparotomy) - - - -	100
(b) <i>Unnecessary</i> - - - -	11
Liver or Kidney only - - - -	9
Retroperitoneal tissues - - - -	2
II. LAPAROTOMY NOT PERFORMED - - - -	51
(Deaths 1)	
(a) Extraperitoneal Hæmatomata - - - -	14
(b) Thoraco-abdominal or Abdominal wound with a Hæmoperitoneum (Liver or Kidney only) - - - -	8
(c) Chest wound with abdominal signs - - - -	6
(d) Buttock wound with a fractured pelvis - - - -	6
(e) Kidney wound (without a hæmoperitoneum) - - - -	4
(f) Localised peritonitis in a wound more than 36 hrs. old - - - -	4
(g) Extra peritoneal wound of the bladder - - - -	3
(h) Spinal wound with paraplegia and hyperæsthesia - - - -	3
(i) Blast injury - - - -	2
(j) Colon (Extra peritoneal only) - - - -	1

It may be seen with the aid of the fore-going table that:—

- (i) 111 had a laparotomy, and 51 a wound excision without abdominal exploration.

- (ii) 11 unnecessary laparotomies were performed; 9 for liver or kidney wounds, and 2 for retroperitoneal hæmatomata. The definition taken for an unnecessary laparotomy has been one in which nothing except exploration was done and in which recovery followed.

- (iii) There were 40 deaths in this series; 39 from the 111 cases which had a laparotomy, and only one from the 51 in which I elected not to open the abdomen.

- (iv) Of the 51 cases treated without laparotomy, 12 had intraperitoneal lesions and of these every case recovered. The remaining 39 had wounds of the structure in close relationship to the parietal peritoneum. Of these one a spinal wound with paraplegia and abdominal hyperæsthesia was the only case which died. Post-mortem examination confirmed the diagnosis that the missile, which had divided the spinal cord, and produced a large hæmatoma anterior to the vertebral column, had not entered the peritoneum.

- (v) In 33 patients there was a wound of the liver either with or without an associated visceral lesion. In only one of these was surgery necessary for the control of hæmorrhage.

- (vi) In 22 patients there was a renal wound either with or without an associated visceral lesion. In only three of these was nephrectomy necessary.

## DIAGNOSIS

It is essential to see the wood as well as the tree, by which I mean a general survey of the patient is the first consideration. What is the state of the peripheral circulation? What is his blood pressure and his pulse pressure? What is his pulse rate?

Practically every case has already been given morphia to allow him to undertake the journey back. With increasing experience and in spite of a considerable reduction of abdominal pain rigidity, an accurate diagnosis can still be made in these heavily morphanised cases.

Further factors to be considered are:—

(I) The state of dehydration of the patient. The majority of gun shot wounds of the abdomen are dehydrated when seen.

(II) Resuscitation. This usually takes a matter of some hours, which enables the surgeon to review the case on more than one occasion; this is important because the clinical picture varies from hour to hour. And I would here mention that a valuable diagnostic pointer is given by the fact that most patients without a lesion of the alimentary tract either do not require resuscitation or respond rapidly. An exception may be made by cases with severe hæmorrhage or associated other first priority wounds.

(III) Fighting-fit soldiers usually have an abdominal wall of high muscle tone, which in itself is a trap for the unwary.

There is no difficulty of diagnosis in many cases; they may show an abdomen with the general rigidity and tenderness, the absence of respiratory movements, and the silence on auscultation of general peritonitis; or there may be a prolapse of viscera through the wound. The problem arises in the less obvious case, and before discussing individual lesions there are two physical signs of fundamental value in all cases. These are:—

- (i) An efficient clinical estimate of the wound track, and
- (ii) Auscultation of the abdomen.

(i) *A Clinical Estimate of the Wound Track.* This can be sub-divided into:—

(1) The pre-operative appearance of the wounds, including the relationship of the exit wound if present to the wound of entry, and a statement from the patient of the posture he was in when hit. This latter is important and explains many unusual wound tracks. It has been my experience that missiles take a straight course from one point to another unless deflected by bone. I well remember a case with a wound just above the right inguinal ligament and the foreign body lying in the right ischium. At operation the only lesion found was a laceration of the hepatic flexure of the colon, and subsequent enquiry elicited the fact that he had been bending to adjust his boot when wounded.

(2) The usual routine clinical examination, particular attention being paid to those symptoms and signs of localising diagnostic significance.

(3) Rectal examination and catheterisation have been of importance in tracing the track of many missiles.

(4) A radiological examination, when available, to locate foreign bodies and to demonstrate fractures. This has been of most value in wounds of the upper abdomen and lower chest where the foreign body may be located in the liver or thorax; wounds of the buttock where the foreign body may be retained in a fractured ileum; and wounds of the extraperitoneal regions.

(5) The findings at wound excision which has been performed on every case. When patients are fit for the theatre and whether laparotomy is to be performed or not, I first of all excise every wound which might have penetrated the peritoneum. This is essential and, in my experience, exploration of the wound track in the operating theatre has been the deciding factor for or against opening the abdomen on many occasions.

We now come to:—

(ii) *Auscultation of the Abdomen.* It is essential to ascertain the presence or absence of peristaltic sounds. These may be mimicked by sounds due to a fluid-gas mixture in the bowel itself, particularly when the gut is distended. These can be reproduced by rolling the patient and listening at the same time, but with experience there is no difficulty in differentiating them from peristaltic sounds. Auscultation of the abdomen has been performed on every case in this series, when necessary on more than one occasion and for two or three minutes at a time, until the presence or absence of peristalsis has been established beyond doubt.

#### AN ANALYSIS OF ABDOMINAL AUSCULTATION

Cases with a Lesion of a Hollow Viscus and Without Peristalsis	-	-	-	-	-	89
Cases with a Lesion of a Hollow Viscus and With Peristalsis	-	-	-	-	-	5
Cases without a Lesion of a Hollow Viscus and Without Peristalsis	-	-	-	-	-	1
Cases without a Lesion of a Hollow Viscus and With Peristalsis	-	-	-	-	-	67
TOTAL CASES						162

The accompanying table shows the relationship of peristaltic sounds to wounds of the hollow viscera. It will be seen that in only 1.5 per cent of those cases without a hollow visceral lesion was peristalsis absent; this case a large posterior extraperitoneal hæmatoma was silent throughout, and was one of the two unnecessary laparotomies performed for extraperitoneal hæmatomata. However, in those cases with a lesion of a hollow viscus 91.4 per cent had no peristaltic sounds. In two cases of small intestine wounds, two cases of wounds of the colon, and one intraperitoneal wound of the bladder peristalsis was heard. In these there was little leakage from the bowel and minimal peritoneal soiling; and I am convinced that peristalsis is only absent when the activity of all the intestine has been inhibited by a general peritoneal soiling. The following case seen in consultation with Lt.-Col. Latchmore, RAMC, illustrates this point well. Machine gun bullet wound 2½ hours before admission, entry anteriorly just to the left of the mid-line at the level of the 6th rib, exit at the level of the 10th rib in the posterior axillary line of the same side. The abdomen was tender but soft, peristalsis could be heard; as the patient was very distressed, he was sat up. This was followed immediately by a complaint of great abdominal pain, so after five minutes he was laid down again. On examination the abdomen now had generalised rigidity and tenderness with complete silence on auscultation. At operation a large tear of the stomach was found, it appears that when this patient sat up his gastric contents which previously had been localised to the upper left abdominal quadrant were spread rapidly over his entire peritoneum, thereby producing the sudden change of abdominal physical signs.

I therefor submit that the absence of peristaltic sounds, confirmed and reconfirmed, is a positive indication for laparotomy; but that the presence of peristaltic sounds is only a valuable guide towards, and not a positive indication for, conservative treatment.

Time does not permit the discussion of the differential diagnosis of all the individual lesions enumerated in the table; I will, therefore, confine my remarks to the groups of cases in which peritoneal penetration had occurred, but in which laparotomy was not performed.

*Wounds of the Liver.* It has been my experience that of 33 such cases in only one was surgery necessary for the control of hæmorrhage. These cases of simple hæmoperitoneum form a large and important group of abdominal war wounds, because they are one of the few intraperitoneal lesions in which laparotomy is not necessary. An X-ray film is invaluable when the foreign body has been retained, as an adequate estimation of the wound track may be impossible without one. In the majority of the



unnecessary laparotomies of this series the course of the missile could not be estimated because an X-ray was not available. The presence of some abdominal wall movement with respiration, of a mild rigidity on light palpation, and of peristalsis by abdominal auscultation have all aided the diagnosis. In no case where the liver was the only lesion was peristalsis absent, although in several patients a large and diffuse hæmoperitoneum was present. These cases have been watched very carefully for further bleeding, but in only one case did this necessitate operation. I would remind you of the case in which hæmorrhage from the liver may be restarted by the laparotomy itself, and in some cases of the extreme difficulty of controlling it again.

*Wounds of the Kidney.* War wounds differ in many respects from the closed traumatic injuries of civilian practice. In the former one does not see the large swelling of the perinephoric tissues, nor does one meet the typical pain and colic at an advanced surgical centre, although the last named has been noted during convalescence. On palpation local tenderness and rigidity can be elicited. Catheterisation is essential, for without exception in this series, hæmaturia has been present. At operation wound excision and exploration will show the track of the missile, and the opportunity is taken for accurate palpation of the kidney. As a result of this

palpation an estimate can be made as to the necessity for nephrectomy, and it has been my experience that the majority can be treated expectantly. In this series, out of 22 renal wounds only three required immediate nephrectomy. It is probable that some cases undergo removal of the kidney at a later date, but they are then better fitted to stand the operation.

*Late wounds.* Patients seen more than 36 hours after visceral perforation differ but little from similar disasters of civilian practice. Four cases had lain on the battlefield for long periods, and upon admission showed localised abdominal signs, findings similar to an appendix mass. The lesions were thought to be of the colon only and they were treated without laparotomy. Subsequently three developed a local abscess which required drainage, and of these two had a temporary faecal fistula.

*In conclusion.* The mortality from unnecessary laparotomy demands the greatest care and accuracy in the diagnosis of abdominal gun shot wounds. Although I have stressed the great value of abdominal auscultation and wound exploration, no single sign, or group of signs should be relied on, without a full and careful clinical examination of the patient as a whole. Finally, where a genuine doubt exists after repeated examinations it is advisable to open the abdomen, but these exploratory laparotomies should rarely be necessary.

## THE TREATMENT OF WOUNDS OF THE LARGE INTESTINE

by

Major H. G. ESTCOURT, RAMC

A feeling that there is a certain amount of disagreement in the air, and that our opinions are not altogether in harmony, has led me to make these few remarks on the treatment of wounds of the large bowel. If they stimulate a discussion that will help to clarify the present position, they will have served their purpose.

During the Italian campaign, as the result of my experiences with an F.S.U., my own views have altered, and I think I can detect a similar change of outlook in the minds of other forward surgeons. Unfortunately, the experience of each of us is bound to be limited to such a small number of cases that opinions formed from their treatment are, at the best, very tentative ones, and it is only by combining our experiences that we can hope to reach definite conclusions. In Italy, I have dealt with 44 patients who have had wounds of the large bowel, 26 of these being complicated by wounds of other abdominal viscera, and 18 being wounds of the large gut alone. This is not a large enough series to allow me to become dogmatic about any methods of treatment, but it has provided me with enough material to make me question the correctness of what I will call for lack of a better term, the official attitude to the treatment of this condition.

I have no wish to quote a host of figures to you, but I should just like to show how the results of the treatment of large bowel injuries have improved, as compared with the last war. For instance, Sir

Cuthbert Wallace, in his book "War Surgery of the Abdomen", published in 1918, gives a mortality of 74% in a series of 85 cases suffering from wounds of the colon and small gut, whereas, in that invaluable analysis produced by Brigadier Edwards and Lt.-Col. Stead, the mortality for the same injury, in a series of 71 cases, was only 50.7%. For wounds confined to the colon there is the same improvement; Wallace's mortality was 48.7%, ours is 36.5%, and the figure given by Mr Gordon-Taylor is very similar to ours—37.2%.

These are encouraging statistics, and the improvement shown by them is big enough to suggest that something we are doing today, that was not done in the last war, is benefiting the patient.

What is it that can be producing this improvement? Well, I think you will all agree that, apart from the various drugs we now use to control sepsis, the two outstanding advances in war surgery of the abdomen in this war have been the introduction of continuous gastric suction and the technique of exteriorising large bowel wounds. There is no doubt that both these procedures have saved countless lives; they have stood the test of time, and they have come to stay.

What I want to suggest to you is that the very great success of these methods has so impressed itself on us, that our views may have got a little out of proportion, and that we are tending to place too much reliance on them to the detriment of a more



common sense surgical outlook. Particularly, I think, is this the case in our reaction to the treatment of large bowel injuries by exteriorisation.

Let me be quite emphatic before I go on to discuss this subject that no one appreciates the value of exteriorisation more than I do. This is in no sense meant to be an attack on an invaluable surgical procedure. Something must be responsible for the improvement shown by the figures I have just quoted, and I am sure that exteriorisation has played a great part in helping to produce that improvement. What I question is not the fundamental soundness of the treatment itself but the great length to which it is suggested it should be carried.

In his book "Forward Surgery in Modern War", Major-General Ogilvie states, "Simple closure of a wound of the colon, however small, is unwarranted; men have survived such an operation but others have died who would still be alive had they fallen into the hands of a surgeon with less optimism and more sense. Injured segments must either be exteriorised or functionally excluded by a proximal colostomy". I wonder how many forward surgeons follow that dictum to-day—not many I believe. The fallacy in that statement seems to me to lie in the fact that the whole of the large bowel is lumped as one entity whereas, in practice, the problems produced by the fixed part of the colon are quite different from those that the transverse and pelvic colon offer us.

Before going into more detail on this point let us be clear on the rationale for exteriorisation. I would say that there were two chief reasons for its introduction:

1. Because resection carries such a high mortality.
2. Because, for various reasons, surgical suture of the colon is rendered less certain and secure than suture of the small gut.

Exteriorisation is something in between these two methods of treatment; it is safer than the second conservative method and, apart from suture, its application requires the minimum surgical interference compatible with the safety of the patient. By a comparatively minor and rapid surgical procedure to be able to render a colonic wound harmless to the patient is a very great achievement and, if it can be done, it is obviously the best treatment. The mobile part of the large bowel provides the perfect anatomical conditions for this type of surgery. Wounds of the transverse and pelvic colon which can readily be brought to the surface, and which can be turned into well spurred colostomies easy to close at a later date, come into this category and are ideal if exteriorisation is required; surgical interference really is reduced to a minimum.

When we come to the fixed part of the large intestine the position is different. Mobilisation is necessary to bring the flexures and the vertical parts of the colon to the surface and when, after a hard struggle, this has been accomplished what a sorry sight our colostomy so often turns out to be, and how pleased we are to know that it is extremely unlikely that we shall have to face the formidable task of closing it, should the patient be fortunate enough to survive for so long. It is in these cases, particularly, that I doubt if exteriorisation should be regarded as the best routine treatment. They carry a comparatively high mortality whatever operative procedure is adopted and I do

not think that exteriorisation has materially helped reduce that figure. The chief reason for this is that extensive mobilisation which sometimes must be very extensive to produce a satisfactory colostomy, is such a shocking procedure, and these war abdomens, who so often have such a precarious hold on life, will not stand it.

I admit that, in some cases, with a very badly damaged segment of bowel one is more or less forced to exteriorise, and that exteriorisation is safer than resection; but there are many less severe wounds in which there is a choice between mobilisation and exteriorisation on the one hand, and suture and drainage on the other. It is in this type of case that I become more and more in favour of the latter procedure.

I think that suture is of particular value in wounds of the cæcum and ascending colon. I have an impression that mobilisation is a more shocking and dangerous procedure on the right side of the abdomen than on the left, and certainly an artificial opening in this part of the bowel only too often provides unsurmountable difficulties.

Extensive excoriation of the skin, spreading sepsis and the difficulty of overcoming the excessive dehydration due to the loss of so much liquid in the stools all combine to add to the mortality. In fact, so poor have been my results from exteriorisation of this portion of the large bowel that I now try to treat wounds of the large intestine up to, and including, the hepatic flexure in the same way as small bowel wounds, with the addition of adequate drainage both of the peritoneum and of the retroperitoneal tissues. I shall refer in more detail to the treatment of wounds of this portion of the large gut when I come to the consideration of the type of wound which is most suitable for immediate closure.

Having satisfied myself by results, that there was justification for this type of surgery on the right side of the abdomen it seemed reasonable to apply it to the splenic flexure and descending colon, always remembering, of course, that suture in this region is not as safe as it is in the more proximal part of the large gut. Even so I think there are some wounds that are safer closed than exteriorised. Whatever incision is employed, be it subcostal, transverse lumbar, or any of the various vertical approaches, mobilisation of the splenic flexure sufficient to give an adequate colostomy is, more often than not, a major surgical procedure associated with a great deal of shock and attended by a definite immediate mortality; especially serious is it in those patients who anyhow must be submitted to a long operation because of the multiplicity of their lesions. I am convinced that some of these cases might be saved if the simpler and shorter method of suture was adopted.

I have said nothing about the late mortality of these cases with difficult colostomies as I have had no experience of dealing with them out here; but that there is a late mortality from war colostomies is obvious from the information I have received through my follow-up cards. I do not suppose it is much, but closing some of them must be an unenviable task. I hope that those of you who have had experience of this work will give us your views. A colostomy may not have the evil reputation it had in the last war when everything was done to avoid producing this condition but, until it is closed, it is always a potential cause of trouble and, if a patient



can safely be saved from its dangers and its unpleasantnesses, it is well worth while.

It is reasonable to assume that some small wounds of the mobile large bowel could also be treated by suture and I believe this is being done by some forward surgeons. A short time ago I had to close a 14-day old burst abdomen in a case a colleague had left in my care. Major Harper had sutured a wound of the proximal transverse colon at the original operation and, when I examined the bowel, I was surprised to see how perfectly healed and healthy it had become in such a short time. By the way, why this patient's abdominal wall gave way remains a mystery but he did very well in the end. Of the two mobile loops of large bowel I think it would be agreed that the pelvic colon gives the better results from exteriorisation and here suture can only hold a very small place. On the other hand the transverse colon does not always give such a satisfactory colostomy, especially when the wound is near one of the flexures. Moreover wounds in this region can easily have their suture line reinforced with omentum which gives one extra confidence when deciding if primary closure is justifiable.

Intraperitoneal wounds of the upper part of the rectum and the distal pelvic colon have to be sutured, and it was the fact that so many of these cases made such a rapid recovery that induced me to be more venturesome in suturing other portions of the large gut. A proximal colostomy is supposed to be an essential part of the treatment of these upper rectal wounds, but when the rectum is injured from in front, without gross damage and without danger of retroperitoneal infection, a colostomy is sometimes unnecessary. It is surprising how common are these small wounds of the anterior rectal wall; they are often associated with a bladder injury which makes a colostomy especially undesirable. In these cases preparation can be made for a colostomy, but the loop of colon left unopened and not fixed to the abdominal wall, so that it is a simple procedure to return it into the abdomen if, as often happens, peristalsis becomes established early and the bowel functions normally.

I should like to say a few words about the type of large bowel wound that seems most suitable for immediate closure as, if this treatment is to be adopted, its success depends entirely on the right choice of case. We all know the reasons why this operation developed such a bad reputation—the thin wall so liable to be extensively damaged, the precarious blood supply, the lack of complete peritoneal covering in some areas, the risk of retroperitoneal infection and the dangerous nature of the intestinal contents should the suture line leak. It is a formidable list, but these same drawbacks are presented to us in civilian surgery and we are not frightened by them. It does mean, though, that our judgment must be sound and that, when we have decided to close a large bowel wound, the operation must be performed with considerably more care than is required for the successful closure of a small intestine perforation. It is obviously asking for trouble to attempt to suture a large area of badly damaged bowel, or bowel which has a doubtful circulation, and a case with concomitant bruising extending to some distance from the wound margin would be equally unsuitable; this last type is unfortunately, not uncommon. Again, wounds involving a non-peritoneal surface, or where there is mesenteric involvement, are best avoided and a

distended or heavily loaded bowel is not in a fit state for anything but exteriorisation. You may think this list is so extensive that it covers most bowel wounds but that is not my experience. Many of the wounds that I see are not of these alarming types and sometimes they are very small indeed with very little damage to the bowel wall and very little bruising. Though they are not particularly common, revolver and machine-gun bullet wounds come in this category and they can almost always be closed. I would say that about 25% of all large bowel lesions, involving a peritoneal surface only, are fairly small and clean-cut wounds, unaccompanied by much damage to the surrounding wall of the gut, and these I would close provided that the other conditions I have already mentioned were satisfactory.

Finally let me stress the point I hope I have already made, that in the fixed portions, of the large bowel where, for various reasons, exteriorisation is more difficult to perform and is not so satisfactory in its results, it is legitimate to attempt the suture of much worse wounds than elsewhere. Particularly is this the case in wounds of the cæcum and ascending colon where, in my opinion, exteriorisation holds a very limited place. Nearly all wounds of the cæcum can be closed and it is very seldom that the bogey of having to deal with a non-peritoneal surface arises. If the cæcum is badly damaged I think it is wise to drain the bowel temporarily by closing the perforation round a rubber tube which is brought out in the flank, either through the battle wound or through a stab.

Wounds involving the anterior surface only of the ascending colon and hepatic flexure lend themselves admirably for suture, and if it is a small wound, I do not drain the bowel. Unfortunately it is more common to meet a wound involving the posterior surface, or a complete through and through wound of the gut. A certain amount of mobilisation is necessary to expose these injuries; but, when this has been done, I have found it a safer procedure to suture the anterior wounds and to close the posterior perforation round a rubber tube that can be brought out into the flank, rather than to perform the much more extensive and shock producing mobilisation necessary for a satisfactory exteriorisation of the affected segment of gut. I must emphasise, of course that drainage of the retroperitoneal tissues is essential in all cases.

There still remain those happily rare cases where the bowel in this region is so extensively damaged that any form of suture is out of the question. Exteriorisation may be the only choice left to us. In two such cases, I short circuited the terminal ileum into the transverse colon and removed the shattered remains of cæcum and ascending colon; one of them got away with it but it is a formidable operation for a war abdomen.

What I have said about the cæcum and ascending colon can also be applied to the splenic flexure and descending colon but, as I have already said, the risks of closure are greater and I would only suture small wounds in this portion of the bowel. It has not been my custom to give these patients a proximal vent though I know that some surgeons perform a routine cæcostomy. All the large bowel wounds that I have closed distal to the hepatic flexure have had such a limited amount of damage to the wall of the gut that I have felt reasonably confident of my suture line, and I have done nothing more than drain them locally.



Personally I have yet to regret suturing a large bowel wound; there are some large bowel wounds I regret I did not suture, and I am sure it is wrong to make a 100% condemnation of this method. In the last war, faced with the alternatives of suture and resection, and knowing how high was the mortality from the latter procedure, suture may have been attempted in cases which were not suitable for such treatment, thereby bringing the method into disrepute. We now have a much more reliable tech-

nique for dealing with this type of wound, and that may well be one of the chief reasons why we have reduced the mortality so considerably. At the same time, in our enthusiasm for new methods, do not let us forget that, both in the last war and in this war, a great many colons have been successfully sutured; I hope I have indicated, not only why I consider there is still a place for this technique, but also why I think it remains the correct treatment to adopt for certain wounds of the large intestine.

## THORACO ABDOMINAL WOUNDS

by

Major G. BLACKBURN, M.B.E., RAMC

I believe there is general disappointment at the results of operations on thoraco-abdominal injuries, but the picture, in my opinion, is not as black as it is painted. I am glad, therefore, of having an opportunity to-day of stating some of my reasons for that assertion, and replying to some of my friends, who have thought me unwise in making it — (even said so in a contemporary medical journal) — I would go so far as to say that thoraco-abdominal injuries are not, in my view, more serious than abdominal I have drawn on my own and my colleagues figures to prove it. My own series is of 40 cases only, but I exclude 8 which were successfully treated without operation, leaving 32. Together with those of Majors Estcourt, Harper, Rob and Wheeler these make up a total of 126 — with 46 deaths.

That represents a mortality of 36.5% — a figure comparable to the average mortality rate of abdominal injuries and very similar to the 34% over 150 cases, which Major Rob and I have reported elsewhere. If the thoraco-abdominal cases treated conservatively are included, the figures are almost identical.

The mortality, moreover, compares favourably with:—

- (1) The figure of 51% from Normandy (June, July and August 1944 — 147 deaths in 292 cases).
- (2) 55 and 63% in Gordon Taylor's two well-known analyses, and
- (3) 60% in Brigadier Edwards and Lt. Col. Stead's analysis here in the first six months of 1944 (47 deaths in 78 cases).

One further fact is worthy of note before passing from figures, pure and simple, to more interesting aspect of the question — and that is the lower mortality of right-sided lesions than left (33.8% against 39.3% or, in figures, 22 of 65 against 24 of 61). This is largely due to the presence of the liver on the right side, for liver wounds, by and large, do well. It has been involved in all 36 right-sided cases of which I have details, and three only have an associated hollow visceral lesion. On the left side, on the other hand, 15 of 30 cases show a hollow viscus injury. These figures are sufficient to remind us of the better results of operations on solid viscera and this single fact, by itself, goes far to account for the similarity in results between thoraco-abdominal and abdominal wounds.

But, as I have suggested already, it is not the figures upon which I wish to lay stress. It is rather some impressions I have gained from the little I have seen and done, which are, I admit, at variance with the short accounts of thoraco-abdominal wounds to be found in the literature available here. To quote Mr. Tudor Edwards "Addomino-thoracic wounds are usually associated with a high mortality". True enough — but what is "high" in this kind of work? And is it of necessity higher than the average abdominal death rate in war? "The fatal character of addomino-thoracic wounds" likewise is a phrase that appears often but I believe it has been based in most writings on the results from the last war. Recent figures from France are an exception, but those of the next quarter will probably be much better if only for tactical reasons.

To quote Gordon Taylor once more "He would be bold who ventured to foretell that, in this province of surgery the zenith of our achievement has yet been attained. Already, indeed, the recovery rate in the hands of a few individual surgeons, whom Luck has perhaps brushed with her wings or who may have been fortunate in other ways, has been of almost astronomical magnitude". He refers there to abdominal results from a theatre other than this, which have already been fully discussed. But the words are as applicable to thoraco-abdominal wounds and it is fair to say that without invoking the goddess or aspiring to the celestial, a figure of 32% or thereabouts should not be beyond us. I look forward to hearing other forward surgeons to-day, who think likewise and who will bear with me in refusing to regard thoraco-abdominal injuries in the traditionally pessimistic light.

Up to this point, I have carefully used the term thoraco-abdominal in preference to addomino-thoracic. It may sound like hair splitting but, in my view, it is the more accurate and bodes less ill. The injuries, after all, are due, as a rule, to metal fragments on their downward path and an entry wound in the chest with a foreign body below the diaphragm is far commoner than an entry wound in the abdomen with a foreign body or exit wound in the chest. The latter, which is truly "addomino-thoracic" is likely to be the more dangerous of the two and a double operation — laparotomy and excision of the chest wound — more likely to be required than in the true thoraco-abdominal type.



More than half my own cases did not in fact require a laparotomy and it is my belief that the less often it is required in thoraco-abdominal injuries, the better are the results. So much is possible through the diaphragm that a good many abdominal explorations can be saved by enlarging the diaphragmatic tear and doing the intraperitoneal portion of the operation through it. Splenectomy is the best example, and I think it is in fact easier by this route than through the abdomen: the accessibility of the lienorenal ligament is so much in its favour. It is likewise not difficult to repair stomach and colon injuries (dare I say without exteriorisation?) by the same approach. On the right side, however, the picture is slightly different and simple diaphragmatic closure is usually all that is involved. I have long since abandoned the policy of plugging the liver (from above or below) and would go so far as to say that masterly inactivity is the treatment par excellence of wounds of this viscus. As for the presence of bile in the pleural cavity, it is not, I think, a serious problem or a feature of grave prognostic significance. Liver failure (whatever that is) in my experience is much more serious.

I have mentioned repair of the diaphragm, which I do in two layers always with catgut. I have also combined it at times with a temporary phrenic crush on the left side. I need hardly say I shall be most interested to hear what is said about that by Lt. Col. D'Abreu, Major Nicholson and others (for I know little if anything of the results). Diaphragmatic hernia at their end is obviously a very different problem from that at the initial operation, where abdominal viscera or omentum project into the thorax and perhaps out of the wound.

I do not propose here to go into the signs and symptoms of thoraco-abdominal wounds but it is pertinent to observe that they are full of surprises and can be most misleading. The absence of gross tachycardia and respiratory embarrassment may be deceptive and the degree of blood loss is not as a rule severe (excluding extensive lacerations of the liver). Shoulder pain may be significant and the pain of what is virtually a strangulated diaphragmatic hernia most indicative.

Operative procedure — where operation is decided — amounts as a rule to exploration of the chest wound first, with or without laparotomy to follow. I have already touched on this point and suggested that where possible, laparotomy should be avoided. When it has to be undertaken, a Kocher's incision (on either side) gives very good access. It is my experience, furthermore, that patients breathe better after operation by this than by a paramedian approach. This I believe to be important, as post-operative pulmonary complications are not uncommon.

The lung lesion in these cases is usually not severe and simple suture is the most that has been required. Contusion of the lung is however common and it is well to bear this in mind when giving intravenous fluid. Pulmonary oedema is so easy to produce and so difficult to treat that I tend to limit venoclysis in these cases even more than in the simple abdominal. There are two reasons:—

- (1) The frequency of solid viscus lesions only and the ability to dispense with gastric suction.

- (2) The damage of water-logging a lung damaged by the missile or indirectly by blast.

Amongst the solid viscera commonly injured the spleen and kidney figure prominently. The picture differs materially from the dramatic picture of rupture in civil life, and bleeding, far from being torrential in character, is often slight and confined to the perinephric space or immediate neighbourhood of the spleen. Even injuries, requiring both splenectomy and nephrectomy, can occur without the blood loss that is usual in tears of the mesentery of the small intestine.

Injuries of the spleen as a rule require splenectomy, but I have twice treated them conservatively — as far as I know without untoward result. Injuries of the kidney, on the other hand, do not as a rule involve nephrectomy. Tears of the hilar region are notable exceptions, and others in whom hæmaturia persists for more than 24 hours after receipt of injury. The matter of exposure merits a word at this juncture and I have had an opportunity of doing it transperitoneally through a Kocher or paramedian, through the diaphragm and through the usual lumbar route. Oddly enough, it presents few difficulties, as the subjects are muscular and not fat as a general rule and adhesions from infection or previous operation unknown. The transperitoneal route, I may add, has one thing to recommend it in the form of an opportunity of manually determining the presence of a second kidney.

There are many other aspects of the operative procedure I could discuss but time does not permit it. I would merely add one word on what I believe to be the great importance of aspiration of air and/or blood before the patient leaves the theatre. The process always has to be repeated in the ward and usually within 48 hours.

The patients, of course, remain the usual ten days and it is my practice to do a primary closure of both wounds after excision when dealing with a through and through injury. Healing has been consistently good. Where there is a retained foreign body, on the other hand, evacuation to Base is the paramount consideration and a man without a laparotomy (e.g. a liver wound only) can often leave in less than the time that a sutured wound or wounds would immobilise him.

To sum up:—

- (1) The term thoraco-abdominal\* is preferred to abdomino-thoracic.
- (2) Of 126 thoraco-abdominal wounds operated upon by five different surgeons, 46 died — a mortality of 36.5%.
- (3) Thoraco-abdominal wounds are not prognostically more serious than abdominal.
- (4) Avoid laparotomy where you can and to the abdominal part of the operation through the diaphragm. If laparotomy is essential, a Kocher's incision gives excellent access.
- (5) Excessive venoclysis is particularly dangerous in this type of injury.
- (6) Transdiaphragmatic splenectomy is as easy or easier than abdominal.
- (7) Conservatism with lesions of the kidney is usually well repaid.



## ABDOMINAL INJURIES AFTER EVACUATION TO A BASE HOSPITAL

by

Lt.-Col. H. W. RODGERS, O.B.E., RAMC

The object of this paper is to give you some sort of picture of these abdominal cases at the base. You must forgive me if I do not give you many figures but my information has been gathered from sources so varied that the accuracy of statistical methods is impossible. These sources are as follows:— A series of about 50 cases observed at No. 69 British General Hospital — another series of about 50 cases observed during the past month in various other hospitals — the death reports reaching AFHQ on cases dying in the latter half of last year — and from my previous experience.

First of all let me give you some gross figures:—

## DISPOSAL

Category B	=	20%
U.K.	=	70%
Death	=	10%

## ASSOCIATED INJURIES

(1) Fractures	=	28%
(2) Severe Flesh Wounds	=	15%
(3) Chest	=	10%
(4) Nerve Injuries	=	10%
(5) No Other Injury	=	40%

Twenty per cent. of the cases were discharged in Category B to Convalescent Depots. Seventy per cent. were evacuated to the United Kingdom, and 10% died (The figure was in fact rather less than 10%). This table also explains why so many were evacuated to the United Kingdom. Only 40% had no other serious injury. Twenty-eight per cent. had serious fracture of such bones as the femur, pelvis, etc. Fifteen per cent. had flesh wounds serious enough in themselves to lower the man's category. Ten per cent. had an associated thoracic injury — that this figure is not higher can be explained by the fact that many of the thoraco-abdominal cases went straight to the chest centre. Ten per cent. had serious nerve injuries, such as paraplegia or sciatic nerve lesion.

I would like to discuss the later progress of abdominal wounds under these headings:— Sepsis, Malnutrition, Dyspepsia, Hernia and Prevention. The survey has been conducted at a rough average of about two months after wounding.

## SEPSIS.

The completion with which intra-abdominal sepsis is overcome can be divided into 5 phases:—

1. The cured are about 50%. They are fit to walk and run and to undergo such a severe test as going for a ride in a 3-ton truck along the bumpy by-roads of the Naples plain. They eat well and their blood counts are normal and they are discharged to Convalescent Depots or sent to the United Kingdom because of other injuries.

2. The second group might be called the convalescents, of whom there are roughly 10%, and as far as their abdomens are concerned, they can best be described as having not quite settled down. They are slightly tender when roughly palpated and they prefer to stay in the hospital rather than travel along

the bumpy roads. They sometimes have dyspepsia and their hæmoglobin and blood counts may be at or just below the lower limit of normal.

3. The third group are the invalids — again roughly 10%. They spend much of the day in bed or lying on top of it. They are more sensitive to abdominal palpation, and sometimes slightly distended, more prone to dyspepsia and lack of appetite. They usually help sister in the kitchen and get rewarded by a few tit bits to stimulate their appetite. They are frequently constipated and usually have a blood count below normal. They are the invalids in blue.

4. The fourth group, another 10%, are the men who are still ill, usually on the S.I.L. or D.I.L. They still have active intra-abdominal suppuration, with bouts of pyrexia, pain, distention and even obstruction. They are wasted, pallid and have low blood counts and possibly low plasma proteins. They will take a long time to recover and may spend a long time in group 3 before improving. This is a dangerous state, and delay in correcting their anæmia or draining abscesses will be harmful.

5. Fatal cases form the fifth group; there were 28 of these during the last six months; all died as the result of intra-abdominal sepsis; some with general peritonitis, usually with multiple abscesses; two of secondary hæmorrhage; four with acute obstruction or after a laparotomy, and four with — that peculiar condition described by Faber in the nineties, acute hæmorrhagic gastritis.

## MALNUTRITION

Coming now to malnutrition. Loss of weight is the chief sign of malnutrition and it was very noticeable that they had all lost weight. When was the weight regained? None that I saw had regained their usual weight with perhaps only one or two exceptions, and many remained considerably under weight. Some had plasma proteins, hæmoglobin and red blood cells below normal, and in a few there were signs of œdema in the lumbar region and ankles. As there was no detectable abnormality in the heart or kidneys, it was assumed that the œdema was due to under nutrition. It was interesting to find that this was sometimes present when the plasma proteins were normal by the copper sulphate method. Oedema of the gut could not be directly observed, but the dyspepsia, which was sometimes present, could have been due to it.

Now there are a few other points which if taken together are, I think, of great interest. These are points of medical interest, and I must ask you to take them with a pinch of salt, and if there are any physicians present, with perhaps two pinches of salt.

These cases often have a secondary anæmia, and in a few cases we have examined, there is a lowered gastric acidity. The tongue occasionally shows atrophic filiform papillæ and on two occasions I thought I saw spooning of the nails. In fact it was a clinical picture rather like the simple achlorhydric anæmia of female civilians.



## DYSPEPSIA

Numerous patients had dyspepsia, of what might be called the obstructive type. I don't suggest that they had severe mechanical obstruction, but they had frequent regurgitation, a feeling of fullness, their appetite was easily satisfied and they suffered from constipation. These are all, I feel sure, organic symptoms but there is no treatment for them, other than treatment of the patient as a whole, and for the patient's mental health, I think they are better disregarded; for I believe if too much attention is paid to them, they may persist; and persist they did after the last war. Most of us who dealt in dyspepsia in peace time can remember them right up to the outbreak of the present war.

## HERNIA

The incidence of incisional hernia is high. The merits of the various incision commonly used may be judged on the hernia rate and the ease with which the hernia can be repaired. Before I go any further, let me warn you that I am in favour of the midline incision. In this you have a moderate rate of hernia but you are left with two intact recti which can be fairly satisfactorily repaired. In the paramedian, the hernia rate is also moderate and the exposed margin of the muscle in the herniated cases appears to be reduced in bulk and such cases are presumably less easy to repair. In the rectus split incision, which is a vertical cut through the muscle and sheath to one side of the midline, the hernia rate is very high — almost 100%. The muscle to the inner side of the incision atrophies and makes repair difficult. Consider for a moment this strip of muscle, cut off by the incision from most of its nerve supply and some of its blood supply, bruised and retracted, rubbed with the septic contents that have leaked from the holes in the gut and sewn up without drainage. You cannot expect it to recover — and it doesn't. I can do nothing but condemn the recent fashion for rectus split incision, which is not even easier to make or sew up than the midline.

## PREVENTION

The prevention of hernia I don't want to discuss any further.

Dyspepsia is better ignored to prevent it becoming an established psychological entity.

The sooner the patient is cured of his sepsis, the less will he be liable to dyspepsia.

*Malnutrition* is inevitable at the beginning and its early correction is important.

I would recommend here the use of a rehabilitative transfusion of blood or plasma before the patient leaves the forward area so that he does not have to make the journey to the base with a low haemoglobin or plasma protein. He should be given good palatable food with a high protein content and persuaded to eat it. He should have iron and, in case they do any good, whatever vitamin tablets you have available. All this should be done early.

*Sepsis.* The prevention of the harm done by sepsis in again a matter of the timely use of drainage, and of the early correction of anaemia or lowered plasma protein. I will now describe an instructive case:—

He arrived at my hospital in an anaemic and septic state having had a gunshot wound of the pelvic colon small gut and caecum. He had a transverse colostomy and a caecostomy, and he was draining faeces from a posterior entrance wound which having transversed his ilium had produced the hole in the caecum. He was very ill and we transfused him repeatedly to get him fit enough for us to do something to stop this posterior leakage of caecal contents. We took several weeks to restore his blood to a point just below the lower limit of normal and then one day he became severely ill, vomited blood and died within 14 hours. Post-mortem examination revealed a huge retroperitoneal abscess into which he had a secondary haemorrhage, and that his haematemesis was due to acute toxic haemorrhagic gastritis. I feel that had we been quicker at restoring his blood picture and increasing the retrocaecal drainage we might have saved the catastrophe.

The great thing is to transfuse, feed, and drain early.

In conclusion I would like to take you back to Hampstead. If you go up to the Heath and pass the coconut shies on your right and the white stone pond on your left and go down the hill to the north, you will come to a large house, lying a little back from the road, where the band used to play on Saturday afternoons. On the side of the house is a large sundial on which is written Spencer Wells's advice in the treatment of these cases, "Do to-day's work to-day."

## INJURIES TO THE COLON

by

Lt.-Col. BENNETT

Thirty-nine cases of injury to the colon were admitted to 3 N.Z. Gen Hosp from 28 Nov. 43 to 5 Jan 45. Five of these had double wounds, at widely separated points of the gut and with the exception of one accidental injury to the rectum, all were due to missiles.

According to the records the severity varied from retro-colic haematoma with or without bruising of the bowel to a complete transection of the large bowel. There were two deaths.

## SITES OF WOUNDS:

The sites of the wounds are shown below.

Right side (including hepatic flexure)	Transverse Colon.	Left side (including splenic flexure)	Rectum
9	7	18	10

## OTHER ORGANS INVOLVED:

In 15 cases the colon alone was injured and in 24 others abdominal or thoracic viscera were also involved.

Colon alone	Colon plus stomach	Small intestine	Small intestine & Thorax	Small intestine & kidney (left)	Small intestine and bladder	Small intestine thorax & spleen	Bladder	Kidney (left)	Liver	Thorax	Paraplegia
15	1	9	2	1	2	2	1	1	1	3	1

## IMMEDIATE OPERATIVE TREATMENT (In Forward Units)

In almost all instances operative treatment by forward surgeons followed closely the procedure recommended in various Administrative Instructions for the treatment of wounds of the colon. The injured colon was either mobilised and brought out, in most cases through a separate incision in the abdominal wall, or, in the case of the rectum, a proximal colostomy was made in the left inguinal region. A Paul's tube was employed in three cases of injury to the right side of the colon.

In two cases of injury to the caecum with retroperitoneal hematoma and bruising, the surgeon was satisfied with establishing wide drainage to the injured area. Subsequently small faecal fistulae formed, which after a short period, healed without necessity for further operation.

In one case of injury to splenic flexure the wound in the colon was repaired and a transverse colostomy carried out. The perforation in the bowel healed satisfactorily and the colostomy was finally closed without difficulty 67 days after the wound occurred.

## IMMEDIATE OPERATIVE TREATMENT (Forward Units)

Exteriorisation with spur.	Exteriorisation without spur.	Proximal colostomy (rectum)	Paul's tube	Drainage to injured colon only	Proximal colostomy (splenic flexure)
21	2	10	3	2	1

COMPLICATIONS AND SEQUELAE during the period between the original operation and the date of final closure or of evacuation to New Zealand.

Faecal fistula	Intra-peritoneal abscess	Retro-peritoneal abscess	Abscess in abdominal wall	Pyopneumothorax	Osteomyelitis sacrum
3	3	4	4	2	2

IN ADDITION: 1 case (fatal)—Urinary fistula (due to damage to left kidney (splenic flexure)).

1 case (fatal)—Abscess of liver around retained metallic foreign body (caecum and ascending colon).

## FÆCAL FISTULÆ:

Two of the faecal fistulae have already been mentioned. The third occurred in a case of complete transection of the fixed portion of the pelvic colon. With difficulty the surgeon brought two short lengths of colon to the surface but recorded that he had trouble in approximating them. The fistula,

which discharged into the wound of entry in the anterior part of the left buttock, developed at the point of greatest tension on the spur. The result was a short spur only, but it was possible to crush this and when the bowel was freed for final suture the fistula was included. A wide drain was placed posteriorly through a perforation in the blade of the ilium and the bowel healed satisfactorily with complete return of normal function.

## INTRA-PERITONEAL ABSCESS AND PYOPNEUMOTHORAX:

Three intra-peritoneal abscesses occurred. They were a pelvic collection and two sub-diaphragmatic abscesses, one on the right side and one on the left. These, like the two pyopneumothoraces, are regarded as results of penetrating abdominal wounds in general and not particular complication of injury to the colon. All were drained successfully.

## RETRO-PERITONEAL ABSCESS AND ABSCESS OF THE ABDOMINAL WALL:

Much more serious complications were those of abscesses in the abdominal wall, either in the inter-muscular layers, or the retro-peritoneal tissues. It is noteworthy that these collections were almost "silent". The indications of their existence were a steady deterioration of the patient's general condition accompanied by a severe persistent almost intractable anaemia. Localising physical signs were few. There were four cases of each type of abscess encountered.

Examination of the records seems to indicate that the main causes were (1) inadequate amount of bowel brought to the surface (2) colostomy brought out through the laparotomy wound (which was an extension the entry wound in all the cases showing this complication). These two causes are more inter-related than at first appears for the reason that these colostomies are open from the outset, in contradistinction to the considered colostomies of civil surgery. Where the edge of the gut did not overlap the skin or where all the tissues of the abdominal wall did not fit closely round the loop of the bowel, faeces were able to seep between the edges of the gut and the wound. Infection then spread along the tissue planes. On the one hand, tension on the loop and on the other, the loose subcutaneous tissues of the laparotomy wound favoured this seepage. If, in addition, the retroperitoneal space had been widely stripped up and was filled with masses of blood clot or tissues infiltrated with blood very extensive abscesses developed.

All but one of these abscesses were successfully drained—the unsuccessful one being an undiagnosed abscess in one of the fatal cases.

No case which had the colostomy brought through a separate incision, or in which the retro-peritoneal tissues had been well drained showed this complication.

## OSTEOMYELITIS OF THE SACRUM:

There were two instances of this complication. In one, a severe accidental injury, the original wound involved the sacrum and a large sequestrum was removed ultimately. In the other, the infection of the bone followed removal of the coccyx for exploration and drainage of the para-rectal tissues. In four other cases in which the coccyx was removed for similar reasons no infection of the sacrum occurred.



## DEATHS:

There were two fatal cases. The first was a case of multiple compound fractures plus injury to the splenic flexure and the lower half of the left kidney. Operation was not performed until thirty hours after the soldier was wounded. The procedure employed was mobilisation of the splenic flexure to form a colostomy but the kidney was not removed. On admission this soldier was almost moribund but he reacted temporarily to resuscitation measures. There was a profound state of anæmia present and it was felt that further operation could not be entertained at the time. He died a few days later and a post-mortem examination forty-eight days after he was wounded showed that a portion of the kidney was still functioning. There was a large retro-peritoneal abscess extending from the region of the splenic flexure to the left iliac region not previously diagnosed.

The second was a case of severe bruising and perforation of the right side of the colon with a machine-gun bullet retained in the liver. He also was very ill for a long time and became very emaciated due to prolapse of the ileo-cæcal valve associated with an inter-muscular abscess in the loin due to backward seepage of fæces at an earlier stage. The cæcum was closed but he died 10 days later, 128 days after being wounded. At post-mortem the condition in the region of the cæcum was satisfactory but there was an abscess cavity in the liver containing 4 ozs of foul pus. This abscess was in close relation to the retained bullet.

The following extract from the AF. W.3118 will serve to show the difficulties in this case:—"Operation 31 hours after wound. Laparotomy through transverse incision—ascending colon confused for 3-4"—numerous perforations. Free blood in the peritoneal cavity. No other obvious bowel injury but much retro-peritoneal hæmorrhage in the right iliac fossa. Cæcum and ascending colon mobilised and brought out of wound. Paul's tube inserted—wound closed."

## LATE OPERATIVE TREATMENT (In Base Hospitals)

In 20 cases the colostomy was closed and normal continuity of the large bowel re-established. There was one death in this group which has been described above. Two cases, also described above, healed spontaneously. Two cases were operated upon in a Base Hospital in Egypt and the remaining sixteen were closed at 3 NZ General Hospital. In addition information has been received of one case closed in New Zealand.

It is outside the scope of this paper to discuss the technique employed except to say that well recognised methods were used, and particular attention paid to gaining the patient's confidence by explaining the result expected from each stage of the closure of the colostomy.

## CLOSURE OF COLOSTOMIES

Self closure	Extra-peritoneal repair without need to crush spur	Extra-peritoneal repair after crushing of spur
2	6	12

## DIFFICULTIES ENCOUNTERED IN MANAGEMENT:

1. Inadequate amount of bowel brought out of the abdomen.

Two hazards were encountered because insufficient gut had been mobilised outside the abdomen. One has already been discussed above under com-

plications, namely abscess formation in the abdominal wall. The second was the added danger of opening the peritoneal cavity during the freeing of the wall of the gut from the surrounding tissues at the time of closure. This accident occurred on three occasions but as it had been anticipated and as the peritoneum was closed immediately no harm resulted in any case. None the less it was an added anxiety.

## 2. Unsatisfactory spurs.

Here again two difficulties had to be overcome, namely, the inclusion of vessels in the spur and the approximation of an insufficient length of gut.

It will be agreed that the characteristics of a satisfactory spur are that it should be at least three inches long, the walls of the bowel should be closely approximated throughout its length and that it should consist of a minimum of tissue.

The dangers of allowing the vascular borders of the two limbs to lie together are only too plain. When the spur is clamped severe pain is likely to occur and the possibility of secondary hæmorrhage or necrosis of the bowel cannot be dismissed.

In several instances pulsating vessels have been felt in the spur. An attempt was made to crush one of these but considerable pain associated with pallor of the mucous membrane of the gut occurred and the attempt was abandoned. Later, as it was found possible to free a considerable length of colon, the colostomy was closed without crushing the spur.

In another similar case after great care the spur was crushed but this procedure was followed by a severe degree of oedema of the edges of the gut. After a long period this subsided and this colostomy too was closed.

The risks of too short a spur are equally great, namely, the likelihood of damage to some other abdominal viscus or of perforation of the bowel.

Civilian experience of resection of the colon by Paul's method plus a limited observation of surgery in recent wounds of the colon has shown that unless particular care is taken, the mobilised limbs of the colon tend to come together with the vascular borders in contact particularly if there is tension due to insufficient mobilisation. Moreover, the supporting of colostomies with glass rods or rubber tubes through the mesentery favours this particular apposition of the two limbs.

It would seem therefore that to be perfectly safe, the two portions of colon should be sufficiently mobilised so that a line of sutures could be placed close to the anti-mesenteric or anti-vascular border for at least three inches. Further, when sutured they should be brought well outside the abdomen, and so stitched to the peritoneum and in addition to the skin margin, that a good portion of the bowel lies outside the abdominal wall.

## PROLAPSE OF THE COLON:

This occurred in two cases on the right side where the opening in the gut was close to the cæcum. In one case, the ileo-cæcal valve was lying on the abdominal wall. The difficulties encountered in that case were those of dehydration and loss of nutriment. Attempts at increasing fluid by the mouth and the use of large quantities of the usual nourishing foods merely increased the looseness of the motions. The further complication of the digestion of the skin added to the problem of management those of pain and lack of sleep in an already debilitated patient. The difficulty could be obviated by closure



of the cæcum at the earliest possible moment—as soon, in fact, as the extent of possible necrosis due to damage of the wall has declared itself. If a Paul's tube is used, the day it comes out would seem to be the optimum time. Freeing of the edges and insertion of a purse—string suture was sufficient to close some cases of this type. As was said above, an early employment of this procedure might have saved one patient.

#### IMPACTION OF FÆCES

In a surprising number of cases collections of hard fæces were found in the lower colon, and in one or two cases these impacted masses caused great pain to the patient and necessitated manual removal. It is easy to understand how under war conditions fæces may lie under the dressings and pass on by peristalsis into the distal limb, a small amount at a time, until a large mass collects. During evacuation from hospital to hospital the usual care of the distal limb of the colostomy is likely to be forgotten. Insistence on washing out the distal limb at regular intervals after the first few days should obviate this difficulty.

#### Summary

I would like to pay a tribute to the excellence of the notes of the forward surgeons, made often, I know, at peak period of work. The fact that almost 60% of these soldiers already have the normal function of the colon restored is an additional acknowledgement of the work of these surgeons who had to perform the original life-saving operation.

Nevertheless, the presence of a temporary colostomy is a continued psychological insult, which should be removed with the least risk as soon as possible.

The more I study these cases the more I am led to conclude that a smooth post-operative course and early and safe restoration of the continuity of the colon will be ensured if:—

(1) Once a surgeon has decided that it is necessary to exteriorise a portion of injured colon, scrupulous attention is paid to the formation of a properly placed spur, and to the bringing of the gut well outside the abdomen through a small incision separate from the laparotomy wound.

(2) Good drainage is provided whenever a retroperitoneal hæmatoma is found.

#### Colonel E. D. Churchill

We have had a most stimulating morning, beginning with the paper of Major Rob, who tells us that unnecessary laparotomy must be avoided; then we had the paper of Major Estcourt who raised the question: "Should official recognition be given to the fact that certain injuries of the large bowel are best closed by primary suture?". Major Blackburn's paper pointed to a more optimistic view point on thoraco-abdominal injuries, and advised avoiding laparotomy when possible, and that splenectomy should be done through the diaphragm, and called attention to the hazards of giving these patients too much fluid intravenously. Then we had the excellent production of Colonel Rodgers dealing with the problems of rehabilitation of these patients at the base, with the dangers of turning them into psychoneurotics. Finally the paper by Col. Bennett. The meeting is now open for discussion, and I am sure these papers deserve consideration from the floor.

## DISCUSSION

#### Major Cleland

I should like to speak on this problem of closure of wounds of the large intestine. It occurred to us that the policy of exteriorising might possibly be modified in such a way that the prolonged presence of a colostomy could be avoided. The first idea we had was that we might close a small hole and exteriorise that portion without turning in into a colostomy. We tried that in one or two cases, but were very disappointed. Then came a case of a small single hole in the region of the hepatic flexion of the colon. We thought: "Why shouldn't we suture this hole and bring out a single wall of the colon?". We did that by making a small incision about an inch and a half long in the flank. This required the absolute minimum of mobilisation. I was anxious about this case, for there appeared to be a slight twist in the bowel: After two days I opened it to act as a safety valve. All that remained at the end of ten days was a slight discharge of fæcal matter. In the course of 24 hours, normal bowel motions returned.

#### Major Benison

I should like to stand four-square with Major Estcourt in all that he has said about closure of wounds of the large intestine in certain cases. I think it is very necessary that this should be brought up today. I think the choice of method of treatment of a wound of the colon depends very largely on where that wound is. It is quite possible in the mobile parts, to do a double-barrelled type of operation, which is easy to close by crushing the spur, but in the fixed parts of the colon in order to get a spur it is necessary to mobilise the colon, which involves opening the tissues planes to a degree which is likely to cause serious consequences. My own personal figures are very small. I hope to be permitted to quote to you the following:— Wounds of the colon I have treated by suture only on eight occasions with no mortality in the forward areas, I don't know what happened to them at the base for the usual reasons! A type of exteriorisation was performed on nine occasions, with seven deaths. Colostomy, with or without suture, was performed on seven occasions with four deaths. This experience prompted me to look around to try and find out by what method my results could be improved. It is not possible to exteriorise some parts of the colon without extensive mobilization, which I consider a very dangerous procedure. I think it is necessary in the fixed areas of the colon to use one's ingenuity, and if the wound is not suitable for suture, perform some modified form of exteriorisation even though this may result in a colostomy which may be difficult to close.

#### Major R. Clarke

I would like to make one or two points. Firstly, I disagree with Major Estcourt about the difficulties and risks of mobilising fixed portions of the colon. Undoubtedly one is dealing with seriously ill and even dangerously ill patients who are only able to stand a certain amount. If the mobilisation is done rapidly, a colostomy of a satisfactory nature could be provided without the operation being very difficult, or the colostomy unusually dangerous to close afterwards. Patients usually suffer more from the wound than the choice of the operation. I would like to say that I have closed ten colostomies, I



would like to say how much I agree with the contents of Major Blackburn's paper that one should approach thoracic-abdominal operations with a rather optimistic point of view. The thoracic approach makes splenectomy much easier. Two other points: one is the attitude growing up amongst Commanding Officers that there is something magic about evacuating abdomens on the 10th day. A great number are unfit for travel on the 10th, 20th or even 30th day. We have to decide for ourselves when they are fit for travel. The longer we keep them, the more they need some of the things which are only available at the base. We have acquired for ourselves the necessary apparatus for doing hæmoglobin estimations, and it has been very satisfactory. We are thus able to get a better check on how much hæmoglobin, blood and plasma is needed by these patients.

*Lt.-Col. Raven*

When wounds of the colon are considered, I think it wise to refer to our civil experience when we learnt to distinguish the difference in surgical behaviour of the proximal and distal parts of the colon. Regarding wounds of the distal colon, I think that the principle of exteriorisation should remain. If there is difficulty in the exteriorisation of a portion of the bowel, suture of the wound, combined with transverse colostomy as a safety measure should be performed.

Regarding the proximal colon, I believe there is a place for the operation of right hemicolectomy in a special type of case. I refer to multiple wounds of the cæcum and ascending colon, or a large ragged wound, with severe hæmorrhage from branches of the right colic or ileo-colic arteries. In such cases, right hemicolectomy, performed quickly, may be a life-saving operation. In cases of recto-vesical injury it is wise to institute a transverse colostomy. It is good to see the gloom dispelled which has surrounded abdomino-thoracic injuries. The trans-thoracic, trans-diaphragmatic route of approach to the viscera in the left upper abdomen is capable of greater development. It is unwise to minimise the gravity of some of these injuries. In some cases torrential hæmorrhage may occur; I refer particularly to wounds involving the renal artery and renal vein, when the resources of the most experienced surgeon may be taxed to the utmost. A practical point of value is to crush the left phrenic nerve before conducting the trans-diaphragmatic procedure. The left kidney as well as the spleen can be removed by this approach.

*Lt.-Col. Gledhill*

Whilst I agree with the general principles of all that has been said by my friends in forward areas I feel that it is very important that we do not establish or attempt to establish any set principle in the treatment of colonic injuries. It is all very well to discuss these minor injuries of the large bowel, for we all know that every one of us can satisfactorily get away with a minor injury of the colon. We have all done it many times, but the judgment required to decide which you can or cannot get away with can only be obtained after a certain amount of time in dealing with these injuries. Therefore, as a principle I think we must still maintain as a hundred per cent. that the first line to follow in dealing with large bowel injuries is exteriorisation or colostomy. The question of mobi-

lisation of the segments is an acute one. I do agree that the procedure is liable to cause a great deal of trauma and danger to the patient, but I do not agree that it is difficult procedure. It only takes a few moments, and it is a procedure which must of necessity be performed when the injuries are severe. The question of the cæcum is an important one, and I think at certain times there is a great deal of worry as to what to do. I don't agree with Major Clarke and Colonel Raven that the operation of right hemi-colectomy should be undertaken without a great deal of thought and discrimination. Many of these cases that have sufficiently extensive lesions to warrant this procedure are extremely ill. I have attempted it on two or three occasions. I have got away with one of them. I have also on two or three occasions exteriorised the whole of the injured area, I may say the damage in these cases was extensive and so does not come into the category of minor wounds of the colon. I have exteriorised wounds of the cæcum with success. It is a simple operation and can be done quickly, and I have several cases in mind. Going back for a moment to Major Rob's paper I think it was most excellent. Consideration of the papers written on abdominal injuries in this war has always given me a certain amount of thought. The matter of the negative laparotomy has very rarely been considered, and I think Major Rob's figure is the best you can ever hope to get in abdominal surgery. The other question I would like to mention is Major Blackburn's paper on thoraco-abdominal wounds. I disagree that the correct approach is through the chest. I think that only if the wound is of such a size that it could all be exposed through the thorax, then it is obvious, that you should go through the diaphragm. It is absolutely essential in abdominal wounds to take X-rays. The location of missiles enables one immediately to place the incision.

*General Monro.*

It usually requires a great deal to get me on my feet, for I am a notoriously bad speaker, but you have shown in this meeting such a standard in your talks that I would like to congratulate this Command. I have not heard at any meeting I have attended, and I have been to a good many, such good common sense talked on these surgical problems. I would congratulate the speakers on their most excellent papers. The majority of you know me, and I realise that a seat in the stalls here, or a revolving chair at the War Office which is my official position, hardly entitles me to speak on technical matters. I am merely a listener. I have had a certain amount of surgery in this and in the last war, and I have seen many pioneers from the Middle East meet again here. You are all miles ahead of a fellow in my position, and I would not dare to speak except on general principles. I would agree with those people who are inclined to go easy on the exteriorisation of the ascending colon. We have got to review our ideas there, and I think you are opening the way throughout this discourse. I think you are making history. This war-time surgery is the basis of advance in surgery, and will reflect itself in civil life. It did so in the last war, and will do so again in this. Just in passing, I would like to say that in the December issue of the *AMD Bulletin* you will see the figures of the recovery rate for the forward surgical units of the B.L.A. printed. Later the figures from this Command will follow. We hope



then to follow that up with a systematic follow-up of the cases we have been able to follow in the U.K., showing what results you are getting. These figures are not printed to induce a spirit of rivalry between Commands. It exists, we all know that. But that is not the idea. There are many in the Corps in very remote places who have not the advantage of attending a meeting like this and like to read what other surgeons are doing. That is the whole object of it. The follow-up in the U.K. has been extremely difficult. The E.M.S. has not got the machinery, but we are on the way to getting this under control. Our civilian colleagues are doing a job under difficult conditions, and have not the advantages of seeing the conditions in which you fellows are working. Now whenever the word "follow-up" has been mentioned there has been a titter round the room. There is very much to be regretted. If a satisfactory follow-up is to be expected the follow-up cards and case notes must be legible. I think the follow-up should be a two-way traffic. Even if you don't get a follow-up card, if you know who treated the case, and you think something is wrong, don't hesitate to write, and use the card both ways. I have had batches of 30, 40, or 50 cards per week from AMD. 2 (Stats) still untouched. I knew this trouble from the last war. We think two or three don't put on addresses. Others wanted to know "if it was a case of sciatica," or "if it had turned out just as they thought." I wrote back and said that these cards are to be used by any medical officer who wants to know anything, even if he only wanted to know if his diagnosis of measles is correct. I am sure it will be better under now. on. Don't get disheartened. Still use the cards. I think you will get them back.

In conclusion I think it may interest you to know of a town in which we captured a German hospital situated in a Belgian civil hospital. The unit that took over found about 1400 cases looked after by a "doktor" who said he was head of a surgical research unit and had under him a team of some 20 to 30 doctors. In a discussion at the Royal Society of Medicine at the last inter-Allied meeting there were four speakers who spoke about surgery in the German army. One speaker who was a P.O.W. for nearly two years in Germany, was a divisional officer who took over this German hospital. He said "I have never experienced such a horrifying

morning. You could smell the hospital a mile before you got to it. A German surgeon was asked how many patients could be got out. As many as possible were evacuated, and about 500 were still left. They were piled in long wards with the beds not adequately spaced but in pairs one above the other. The majority of the limb wounds were in plaster with pins projecting through the plaster in various directions. Drainage tubes at least an inch in diameter were sticking out of every possible wound. The place was stinking. There were tins intended to catch pus dropping from the top cot to the lower one, and overflowing on to the floor. It is inconceivable from this description that such a thing can occur. The windows of the main ward had not been opened for 6 months, and the whole place was just dreadful."

Well I feel I had to tell you that to show you that whatever else Naziism has done, its surgery is right back to pre-1912. That is nothing much to compare with what you are doing. You are doing marvellous work. The Director General particularly asked me to give you his felicitations and regards and to wish this conference success, and I do think I will be able to go back with lovely memories of what I have seen so far. I am sure the rest will be on the same very fine level.

*Brigadier Edwards.*

Several speakers have referred to the "official view". When I listened this morning to these magnificent papers, and magnificent they were, I felt there was no need for an "official view" (hear, hear), and I am sure Brigadier Stammers will agree with me on this. Surgery cannot be just a routine, although under war conditions a pattern is essential. As regards the question of exteriorisation, we have had a routine, which has never been put on paper in this Command, — that of exteriorisation of all wounds of the colon. Experience during the past year and more has shown us the weak points in such a routine. I would ask you, however, not to discard the routine lightly, and would summarize the lessons learned from today's papers in this way:—

Exteriorisation is the operation of choice for all wounds of the left colon. Some wounds of the right colon, including the cæcum, may, however, be best treated by suture and cæcostomy and drainage.

## ANÆSTHESIA IN ABDOMINAL OPERATIONS

by

Lt.-Col. BERNARD JOHNSON, RAMC

There have been many advances in the treatment of the wounded man in this war. The advanced surgical centre, penicillin, pentothal are but only a few. There is, however, one direction in which we have not made any advance, in fact beware lest we regress. I refer to the anæsthesia for laparotomy in the severely wounded. The standard anæsthetic, for such cases is often deep etherisation. We human beings are strange creatures indeed, for if you, ask the average experienced surgeon or anæsthetist as I have often done, "Do you ever use local anæsthesia?" the answer is invariably "Oh

yes! always for my severe or desperate cases". If the gravity of the case is the result of metallic fragments and not the perforation of a bleeding ulcer or the ravages of some malignant growth should we change our tactics? If so, I wonder why? Perhaps we have not had time to think. Perhaps the excitement and swirl of modern war have made us fearful to deviate from the narrow path we tread. A path no doubt laid down by rush and fatigue at a time when we were bearing burdens—and bearing them well—which, on reflection, seem greater than we should have borne. Let us, therefore, in the peaceful



atmosphere of this room try to resist our impressions and re-marshal our facts. It will not be amiss if we begin by reminding ourselves of some of the effects upon the human body of inhaling 10% ether vapour in air. Let us not deal with the possible or probable effects, many of which may be open to doubt. Let us only recall those disturbances of the normal physiology which we know beyond all doubt occur as the results of etherisation. We must of course remember that the effects of inhaling ether vapour occur whatever concentration is inhaled, but it has been shown that all the reactions to the drug become marked when the vapour exceeds a concentration of 8%. Furthermore these reactions are increased as the etherisation is prolonged. I do not propose to take up your time dealing with the question of loss of consciousness produced by ether, but rather let us note its effect in turn on the cardiovascular system, the kidneys, the liver and the blood, four of the principal systems of the body which all show definite reactions to injury no matter what part of the body is injured.

No one can fail to be struck by the obvious vaso-dilation associated with etherisation. This is due to a local action of the drug on the capillaries and may persist as a sort of vascular paralysis for some hours after the administration of the drug has ceased, especially if the administration has been prolonged. It has been shown that ether can reduce the vasomotor tone in the extremities almost as efficiently as sympathectomy. Apart from giving the patient a nice pink colour and therefore us, a false sense of security, what are the effects of this vaso-dilatation? Firstly there must be an increased heat loss. I need hardly remind you of the efforts that have been made to conserve the body heat from the moment the wounded man is picked up. In the forward areas we can not always ensure that our operating theatres will be very warm, nor can we always guarantee that when the patient leaves the theatre his surroundings will be such that this artificial ability to lose heat, which remember, may persist for some hours, can be discounted. Secondly this vaso-dilatation assists in the reduction of plasma volume, a point I will refer to later. Thirdly, since there is a vaso-dilation the body calls for an increased cardiac output. But ether is depressant to cardiac muscle, decreasing its contractability and the force of heart beat. We see, therefore, greater demands being made upon an organ already measurably jeopardised. Seemingly then, as far as the cardio-vascular system is concerned, ether is not the anæsthetic of choice.

Now consider the kidneys, those organs which are of such interest to us owing to their not infrequent trick of failing to function following injury to some other part of the body. Various workers claim to show intracellular changes in one part or another of the kidney following the administration of ether. Be that as it may, one fact we do know, and that is that deep ether anæsthesia notably reduces the urinary output. The fact that this decrease is due, partly to increased absorption of fluid by the tissues and partly to constriction of the renal capillaries may or may not be of import to mention now. The point I wish to make is that ether definitely disturbs the function of an organ already subjected to strange and unknown factors, factors, which unaided by ether, may cause anuria. Surely we must avoid any possible encouragement to the onset of this terrible condition.

The liver shows some specific reactions to ether anæsthesia which are so marked that they deserve our thought and consideration. I do not think there is as yet a great deal of accurate and reliable information about the reactions of the liver to severe injury of the body. But it is, I think, generally accepted, that if the body receives a severe injury there is an outpouring of glycogen from the liver, and also certain abnormal substances are found to be present in the blood, from which they can only be removed by hepatic activity. In fact there is every reason to suppose that considerable disturbance of normal hepatic function takes place. I sometimes wonder if hepatic disfunction may not be a factor, if not the factor, which causes the gradual post-operative failing and eventual death in those, not infrequent cases, which, on post mortem examination, reveal no obvious cause of death. That, however, is purely surmise, let us dwell only on facts, and the fact is that etherisation causes depletion of hepatic glycogen. One worker showed that the liver loses one half of its glycogen during the first hour of deep etherisation. And further, that he could produce hepatic degeneration by depleting the liver of its glycogen and then subjecting the animal to deep etherisation. Ether anæsthesia decreases the excretion of dyes by the liver, and this decrease persists for 24 hrs. in the normal liver after the ether is withdrawn. The liver of the badly wounded man seems to be called upon to perform a strange and mighty task when he is anæsthetised by ether.

Now let us just briefly remind ourselves of the effect of ether on the blood. Two known changes take place which must attract our attention, especially when considering the matter from the point of view of dealing with the type of case we have in mind. The first is the acidæmia which occurs, there being a marked lowering of pH and a fall in the alkali reserve. I need not remind you of the effects of this on general metabolism. The second is a definite inspissation of the blood revealed by an increase in Hb% and the red cell count, which may increase by as much as 15%. It is obvious therefore that ether does much to delay the return to normal of the blood chemistry and volume.

I will not devote any time to consideration of that old old problem — the effects of ether anæsthesia on post operative pulmonary complications.

For surely we have reviewed the pharmacology far enough to be forced to conclude that ether attacks our patient at all his most vulnerable points and is by no means the anæsthetic of choice for the severely wounded man. That, gentlemen, is exactly the conclusion our fathers came to in the last war, so we can hardly claim to have made a very brilliant discovery. We should perhaps hang our heads in shame, for it appears we have either ignored or forgotten their teaching. We can hardly claim forgetfulness, for scattered through the theatres of war are those lumbering machines designed by Boyle in 1917 in an effort to reduce the amount of ether administered. What alternatives to deep etherisation have we in our armamentarium which will produce satisfactory relaxation of the abdominal wall and not produce, in an already badly shaken physiology, the serious reactions we have just enumerated? Unfortunately our resources are small. The most ardent supporter of high spinal anæsthesia is forced to admit that, for mechanical



reasons alone, it is impossible to apply this form of anaesthesia to the vast majority of our badly-wounded cases. We do not have to be associated with this class of case for very long to learn the limitations of pentothal. The marked anoxia required to produce satisfactory anaesthesia with nitrous oxide and oxygen is even more lethal than pure chloroform. In the near future there is every reason to hope that preparations of curare will come to our aid, but for the present we must endeavour to minimise the effects of ether or to be content with a method we know not to be the best.

The place of novocaine in abdominal section was a very minor one in England prior to 1924. In that year Apperley, who had seen Finsterer—that master of local anaesthesia—performing major abdominal operations under “local” with such amazing results, published a paper on local and light general anaesthesia for abdominal surgery. The practice spread very slowly through the British Isles till 1932 when Finsterer visited the country and fanned the glowing embers into flame. Up to the outbreak of this war I think I would not be exaggerating if I said that major abdominal operations in practically all the big surgical centres in Europe and USA were performed under local and light general or high spinal anaesthesia. Deep ether anaesthesia being avoided. It is of interest and importance to note that the great Wilkie, whose judgement and teachings are so much respected, asked that local and light general anaesthesia might be the anaesthetic when he submitted to laparotomy. Needless to say his wish was granted. I have heard it said and seen it written that local anaesthesia has no place in forward surgery. On what grounds that statement is made I do not know. I can find no evidence of it being tried extensively. A few cases here, a few cases there, yes! but no real persistent test has, as far as I know, been made. Personally, my own limited experience has led me to believe that there is a place, a very big place, in forward surgery for local and light general anaesthesia. In fact I would be at a loss for acceptable arguments were I asked to defend the opposite opinion. But for one reason or another the method has either been discarded or, more usually, never attempted. There are many good reasons for this in war—lack of proper apparatus, etc., but chiefly I believe it is lack of confidence in the method before it is attempted. The excuse most frequently offered is lack of adequate syringes and needles or that the method is too time consuming.

Whatever may have been the position in the past there is now an ample supply of sets of Labat syringes and needles to be had for the asking. One per cent. novocaine solution is easily obtained by diluting the standard novotox with an equal volume of sterile normal saline—supplied ready sterilised by the F.T.U! Let us give the question of time a little unbiased examination. Now it takes from 10 to 20 minutes to do what is commonly called “an anterior abdominal wall block.” That is to inject novocaine into the sheath of both the recti deep to the muscle. I say 10 to 20 minutes for some abdominal walls are more difficult than others—the thin are easier than the fat, and some administrators are slower than others. With practice and with everything at hand it may not take much more than five minutes. But still, for the sake of argument let us say that it takes  $\frac{1}{4}$  hour.

Now it is not often that a surgical team doing priority one and two cases is so pressed that it must work continuously for 24 hours. But suppose that were the position and that during a 24-hour period they had only abdominal cases—a most unlikely occurrence—and that each case took a total time of  $1\frac{1}{2}$  hours. The team would then operate on 16 cases. But if each case took  $1\frac{1}{4}$  hours then the turnover would be reduced to 13.7 cases—a reduction of only two. When we consider the matter on more usual lines, i.e., 8-hour operating periods, but still all abdominal cases, we find the turnover to be 5 cases  $1\frac{1}{2}$  hours each or 4.6 cases  $1\frac{1}{4}$  hours each. Not, I think, an alarming fall in turnover. And of course when we apply the principle to the “mixed bag” of cases usually met, the extra time expended over the few abdominal cases can hardly need consideration when viewed in relation to a whole operating session and the great advantage to the individual patient. Some of you may wonder why the suggestion of light general plus local anaesthesia has been made. Why not local only? The answer is that, apart from some general anaesthesia being required for the treatment of wounds other than the abdominal one, a light plane of general anaesthesia allows of quicker examination of the abdominal viscera. For under local anaesthesia alone the patient is conscious of transmitted vibration and will be disturbed by any traction on the mesentery unless it is very gradually applied. Under existing conditions, the most satisfactory method we have available for producing light anaesthesia is nitrous oxide oxygen ether. Remember that the effects of ether become more marked as the concentration increases. The more practised the anaesthetist the less ether will be used. In my opinion cyclopropane is the ideal adjunct to the local anaesthetic, but at present this is not available in sufficient quantities to issue it to all units, nor are there suitable machines with which to administer it. The War Office, however, has now consented to send six more such machines to this theatre and they will be distributed to those forward surgical centres who desire to try the technique. As a result of this experiment I have no doubt that every surgical team will demand that cyclopropane be made available to them. So loud will be the chorus that the Treasury will be forced to loosen the purse strings. In the meantime I ask you most earnestly to give this question your very serious consideration and practical trial with the tools available. Now, while the amount of work is small, we have the ideal opportunity to become more familiar with the technique and give the method a proper trial. Do not reserve it for the almost hopeless case. If you agree that deep etherisation is a serious handicap to the very ill patient, why not avoid that handicap for the less seriously afflicted?

I am aware that I have brought you nothing new to-day. What I hope I have done is to rekindle your enthusiasm for something that is old and tried. Tried, it is true, under different conditions to those under which we work. But surely it is the proud aim of our profession to bring to the wounded soldier all the advantages of modern medical science. Unflagging determination and boundless ingenuity have achieved this to a degree undreamed of five years ago. That determination and ingenuity are still alive and virile. It only remains for you to say: “This shall be done.”



# A SUMMARY OF THE RESULTS OF ABDOMINAL SURGERY IN C.M.F.

by

Lt.-Col. J. R. St. G. STEAD, RAMC

The purpose of this paper is to present a summary of the results of 560 abdominal battle casualties operated upon in the forward areas in Italy between 1st January and 30th June, 1944. The cases were treated by units of the United Kingdom, Dominion, Indian and certain Allied forces; the terrain over which fighting occurred varied from mountains to plains and beaches; some cases were treated in mid-winter and others in mid-summer; the lines of communication and administrative arrangements varied as much as the degree of pressure under which the cases were done. With so many factors so variable, mere statistics can be of little value in assessing any one form of treatment or modification of operation technique, and the figures should therefore be regarded as representing the results of treatment of abdominal casualties by the Army Medical Services in Italy.

The notes of the cases forming this series were obtained from three sources. The principal source was the accounts of abdominal cases included in the monthly reports of the surgeons who had operated

upon the patients. Another source was the field medical cards of patients who had died in the forward areas. The third source was the documents of those patients who had died in Base Hospitals.

It is not known what proportion of abdominal cases operated upon during the period under review are included in this series. Certain units known to have been engaged are not represented, and others did not report all the abdominal cases operated upon. It is considered, however, that a series of 560 unrelated cases is probably representative of the work as a whole. The only reason for rejection of a case was lack of precise information in these notes.

An alphabetical list of the patients' names was made, including the last three figures of the regimental number, in order to avoid confusion with very common or very difficult names. Each case was then given a serial number for convenience in grouping and counting. The information obtained from the case notes was tabulated and this table formed the basis of the analysis.

TABLE 1 Analysis of Cases of Abdominal Battle Casualties and Battle Injuries

SITES OF LESIONS	WITH ASSOCIATED INJURIES			WITHOUT ASSOCIATED INJURIES			TOTAL		
	Cases	Died	% Mortality	Cases	Died	% Mortality	Cases	Died	% Mortality
SINGLE VISCUS INVOLVED									
Stomach . . . . .	5	4	80.0	7	1	14.3	12	5	41.6
Small intestine . . . . .	47(11)	27(6)	57.4(54)	69(10)	24(7)	34.8(70)	116(21)	51(13)	43.9(65)
Colon . . . . .	18	11	61.1	52	19	36.5	70	30	42.8
Rectum . . . . .	7	3	42.8	12	5	41.6	19	8	42.1
Bladder . . . . .	4	1	25.0	5	Nil	Nil	9	1	11.1
Liver . . . . .	8	1	12.5	25	10	40.0	33	11	33.3
Spleen . . . . .	3	3	100.0	6	1	16.6	9	4	44.4
Kidney . . . . .	5	1	20.0	12	4	33.3	17	5	29.4
Total	97	51	52.5	188	64	34	285	115	40.3
TWO VISCERA INVOLVED									
Small intestine+Stomach .	1	Nil	Nil	4	3	75.0	5	3	60.0
Small intestine+Colon . .	24(5)	17(3)	70.8(60)	71(15)	36(9)	50.7(60)	95(20)	53(12)	55.7(60)
Small intestine+Rectum .	3(1)	2(1)	66.6	12(2)	7(1)	58.3	15(3)	9(2)	60.0
Small intestine+Bladder .	Nil	Nil	Nil	4(2)	1(1)	25.0	4(2)	1(1)	25.0
Small intest.+Solid viscus.	1	Nil	Nil	11	4	36.3	12	4	33.3
Bladder+Rectum . . . . .	1	1	100.0	4	1	25.0	5	2	40.0
Solid viscera . . . . .	1	Nil	Nil	5	1	20.0	6	1	16.6
Total	31	20	64.5	111	53	47.7	142	73	51.4
MULTIPLE VISCERA INVOLVED									
Multiple viscera . . . . .	16	15	93.7	51(2)	32(2)	62.7	67	47	70.1
WITHOUT VISCERA INVOLVEMENT									
Wounds of peritoneum . .	3	2	66.6	8	Nil	Nil	11	2	18.1
Hæmo-peritoneum . . . .	9	7	77.7	1	Nil	Nil	10	7	70.0
Retro-peritoneal Hæmotoma	5	1	20.0	18	4	22.2	23	5	21.7
Negative Laparotomies . .	11	3	27.2	11	2	18.1	22	5	22.7
Total	28	13	46.4	38	6	15.8	66	19	28.8
Grand Total	172	99	57.5	388	155	39.9	560	254	45.4

Figures in ( ) denote Resection of Small Intestine

All cases have been divided into two main groups of which one contains cases with abdominal lesions only, and the other of cases in which there are associated injuries which might affect the result. Penetrating wounds of the head and chest, major fractures and extensive soft tissue wounds are included in these associated injuries. It will be observed that in this series extra and intra-peritoneal lesions of the bladder and rectum have not been differentiated, and renal lesions have been included.

The over-all mortality in the series of 560 cases was 254 or 45.4%. TABLE 1. This table shows the analysis of the cases according to lesions. It is divided into four groups, of which the first consists of cases in which a single abdominal viscus is injured, the second of cases in which two viscera, and the third of cases in which more than two viscera are involved. The fourth group is made up of cases in which no visceral lesion was found at laparotomy. The cases counted as negative laparotomies are those in which the operation notes definitely state that nothing abnormal was detected.

Most surgeons present have already had an opportunity of studying these figures and I do not propose to go through them in detail. It will be seen that even in a series of this size the numbers of certain single lesions and groups of lesions are so small that the percentage mortality is of little significance. One may perhaps draw attention to the figures for lesions which have been discussed during the morning. Of 70 cases in which the colon was the only abdominal viscus injured 30 (42.8%) died. The mortality was 61.1% in 18 cases associated with other injuries, and 36.5% in uncomplicated cases. It is interesting that the mortality is approximately the same as that for lesions of the small intestine—51 (43.9%) in 116 cases; it should be pointed out, however, that a much larger percentage of small intestine wounds had associated injuries, and the mortality for 69 uncomplicated cases was 34.8%.

The mortality for cases in which solid viscera only are involved might cause surprise, but again, the numbers are small and the results of a larger series are required before comment is justifiable.

The second and third groups, as is expected, have a higher mortality. The totals in each group give some indication of the proportionate size of the group.

The fourth group has been discussed during the morning. The nomenclature in this group was adopted as representing most accurately the condition described in the operation notes. Laparotomy was performed upon 45 cases (8% of the total of 560) in which no intra-peritoneal lesion was found with a mortality of 22%. The totals for the two main groups are as follows:—of 172 cases with associated lesions 99 (57.5%) died; of 388 without associated lesions 155 (39.9%) died.

Among the factors which might influence results in abdominal cases the time lag between wounding and operation has always been considered of great importance. FIG. I. Four hundred and fifty cases in which the time lag was stated were grouped on a 6-hour basis. Three hundred and nine (69%) cases were operated upon within 12 hours of wounding and 373 (83%) within 18 hours. The mortality is represented by the shading in this figure. It will be seen that the later groups are

extremely small. The rise in mortality is very marked after 18 hours when represented as a curve FIG. II, but as the later groups are so small the percentages may give grossly exaggerated impressions.

Other factors such as resuscitation, operating time, anaesthesia, modification of technique and post-operative care not reported upon through lack of precise information.

The interval between operation and death was recorded in 291 cases. FIG. III, 160 (55%) patients died within 24 hours of operation and of these 94 did not survive for more than 12 hours (14 of them died during operation). From 2nd-10th day there were 97 (33%) deaths, and 34 (12%) patients died after the 10th day.

A diagnosis of the immediate cause of death was available in only 89 cases, in 68 of which autopsies had been performed. Of the 160 cases where death occurred within 24 hours 15 had autopsy and the cause of death was recorded as shock in eight of them, hæmorrhage in three, peritonitis in two. Blast lung and gas gangrene were the diagnoses in the remaining two.

The causes of death in 50 cases in which death occurred 2-10 days after operation are shown on the following list:—

	No.	P. M. Per- formed
Renal insufficiency	13	4
Pulmonary embolus	7	5
Peritonitis	8	8
Gas gangrene	4	2
Pulmonitis	4	2
Paralytic ileus	2	1
Mediastinitis	2	1
Cerebral contusion	2	2
Asphyxia—f.b. in larynx	1	-
Right-sided heart failure	1	1
Shock	1	1
Pancreatitis—fat necrosis	1	1
Secondary hæmorrhage splenic artery	1	1
No cause of death found	3	3
	50	32

Renal insufficiency appears to be the most important cause of death in this group. The importance of this condition may be exaggerated by this series, firstly because it is easily diagnosed, secondly, because at the time this condition was causing anxiety and it is probable that all cases in which it occurred were recorded. On the other hand a diagnosis was available in only half the cases in which death occurred from the second to tenth day. Therefore, the proportion of cases of renal insufficiency to other common causes of death, e.g., peritonitis, is probably unduly high in this series of 50 cases. The diagnosis was confirmed by autopsy in only four cases and no histological reports are available. It was observed that renal insufficiency had an appreciable incidence only in the summer, whereas peritonitis occurs in all seasons, and is probably the commonest single cause of death in the 2-10 day period. Paralytic ileus was recorded only twice and fatal pulmonary complications occurred in four cases. The other causes of death are due to associated injuries or may be considered accidental.





FIGURE I

The distribution of 450 cases grouped in time intervals up to 48 hours after operation, and the mortality of each group.

## PERCENTAGE

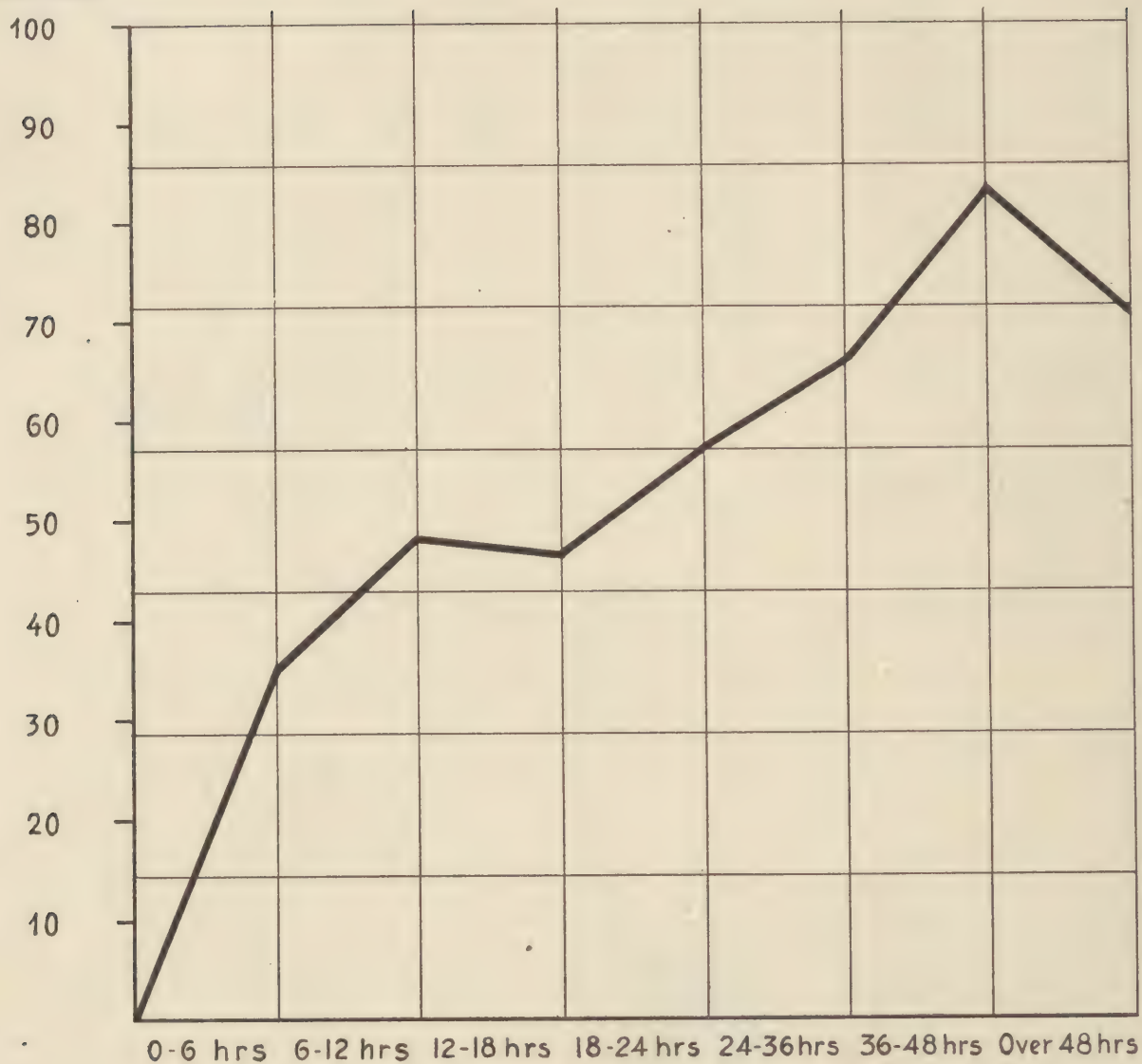


FIGURE II

The relation between time of operation and percentage mortality. As explained in the text, this must not be taken unreservedly as absolute evidence of the value of early operation.



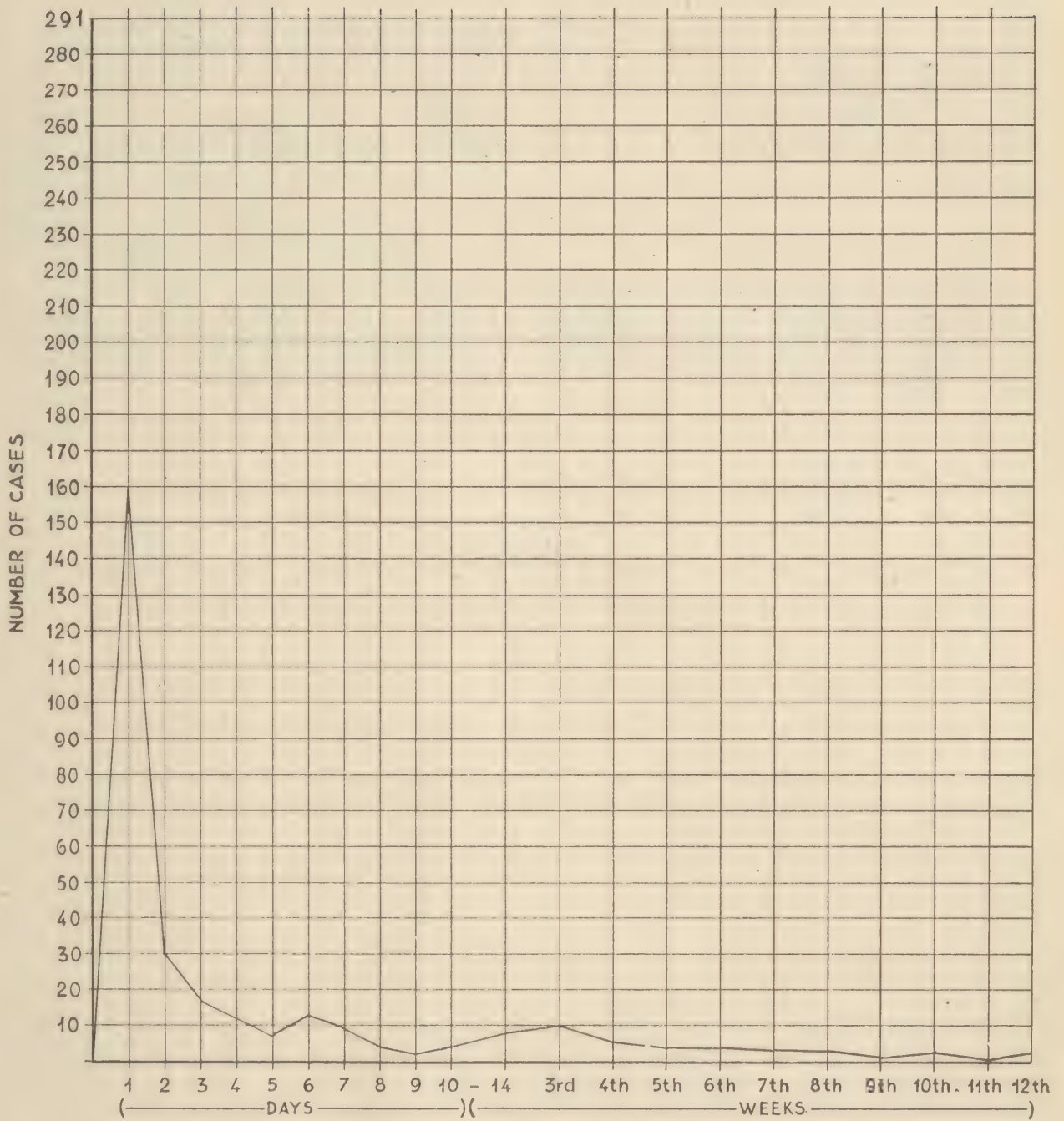


FIGURE III  
Time interval between operation and death in 291 cases

Of 34 cases in which death occurred after the tenth day the diagnosis was stated in 24, and confirmed by autopsy in 21.

FIG. 5.

	No.	P. M. Per- formed
Peritonitis - - - - -	11	10
Lung abscess - - - - -	2	1
Secondary hæmorrhage - - - - -	2	2
Osteomyelitis pelvis - - - - -	2	1
Streptococcal meningitis - - - - -	2	2
Tuberculous broncho-pneumonia - - - - -	1	1
Pulmonary embolus - - - - -	1	1
Liver abscess - - - - -	1	1
Acute intestinal obstruction - - - - -	2	2
	24	21

At this stage infection is almost the only cause of death. Peritonitis is by far the most common lesion, and although other infective lesions are quoted as the immediate cause, they were almost invariably associated with, or complications of, peritonitis.

These figures emphasise four facts.

1. That when the rejection rate of forward surgeons is almost negligible there is a very high mortality within 24 hours of operation.

2. That infection, usually peritonitis, is by far the commonest cause of death after 24 hours, and almost the only cause of death after the tenth day.

3. That there is an appreciable mortality (12%) after the tenth day.

4. That in the period under review renal insufficiency appeared as an important cause of death, although accurate information regarding the aetiology and pathology of the condition is not available.

This, then, is the bald statement of results in terms of survival and death in this series of 560 cases. Surgeons who have published their own series have sometimes claimed better results. This is to be expected as by the time a surgeon has collected a sufficiently large series to justify publication his experience is above the average. The results in this series compare favourably with those of similar series so far published by British surgeons and they require no apology.



Wednesday, 14<sup>th</sup> February 1945

AFTERNOON SESSION

**Clinical Meeting at  
No. 10 (Br) Convalescent Depot**

*Presiding:*

Brigadier W. Rowley Bristow





# THE ORGANISATION OF A CONVALESCENT DEPOT

by

Lt-Col. T. F. BRIGGS, RAMC

The function of a convalescent depot is twofold. Firstly, the restoration of sick and wounded to complete physical and mental health in the shortest possible time. Secondly, to treat those cases whose recovery will not be complete and whose ultimate disposal will be recategorisation and recommendation for suitable employment.

The work of grading and the disposal of convalescents needs considerable judgment and is best performed by those medical officers who have had experience of duty in forward areas, and fully understand front line conditions. The O.C. division of a convalescent depot must be a sound clinician, a judge of character, a good disciplinarian and must possess a personality in which tact and firmness are adequately balanced. In those patients who have been exposed to the strain of battle for long periods, there is in some cases an understandable reluctance to return, and these men are amongst the most difficult cases with which a depot has to deal. The importance of obtaining first class medical officers is emphasized by these cases.

It is certainly my own experience, as I am sure it is the experience of many others, that the facilities of convalescent depots are not fully realised. Patients could in many instances be received from general hospitals earlier than at present, with a resulting clearance of hospital beds, and this is particularly the case when a rehabilitation wing is attached in which full physiotherapeutic measures can be carried out.

On the other hand, convalescent depots should not be used for cases which, having gone through the whole range of physiotherapy for many weeks in a general hospital are referred to the depot with a recommendation for the continuance of measures which have already proved completely unsuccessful. This is the type of case in which early decision as to disposal is essential, and, in my opinion, this decision should in most cases be made before the patient leaves the general hospital. The sooner a decision is made, the sooner the man becomes employed, even if the employment be in a lower category, with the consequent prevention of many of the chronic hospital types who are far too frequently seen. At a recent board I saw an infantryman who with two years' service abroad had served for one month only with his battalion, the remainder of the time having been spent in general hospitals, convalescent depots and I.R.T.Ds. This man could have been downgraded many months before with benefit both to himself and to the general war effort.

No. 10 (Br) Convalescent Depot consists of the normal 2,000 bedded depot with an officers' wing of 50 beds. In addition are attached No. 11 Hospital Expansion and No. 1 Rehabilitation Wing. Both attached units are housed in the depot buildings, and the three units work as one. This combination has, during the last five months worked extremely well, and, certainly in depots situated near hospital centres, might well be adopted as the standard convalescent depot.

The hospital expansion of 100 beds expanded to 200 beds, was originally attached for malaria cases, but after the malaria season was over, was used for light medical, and later, for surgical cases. Infective hepatitis and malaria were sent as soon as afebrile, and thus relieved general hospitals at a very busy period when many casualties were coming from the line. In addition, when hospitals in this area started cold surgery in October, the hospital expansion took cases, particularly of internal derangement of the knee and hernia, very shortly after operation and this ensured a more rapid turnover in the general hospitals. Cases have been received as early as six days after operation and the average is now ten days.

The Rehabilitation Wing has a specialist in physical medicine and six physiotherapists of which one is specially trained in occupational therapy. It consists of physiotherapy and occupational therapy departments with A.P.T.C. instructors specially trained in rehabilitation work. Occupational therapy in this depot is therapeutic only and is prescribed in accordance with the disability it is desired to improve. The use of the occupational therapy department for purely diversional means is not carried out partly through an extreme shortage of materials, and also it is considered that by restricting it to a therapeutic use more individual attention can be given to the patients employed. Should larger quantities of material become available the department would be extended. Diversional therapy is carried out in the hospital expansion with materials supplied by the British Red Cross.

Several alterations to normal convalescent depot routine have been made of which the following may be worthy of notice:—

(1) *Depot Grade 1F.* In addition to normal depot grades of graduated physical training, it was felt that a standard test, particularly for the infantry soldier, was necessary. This test consists of an assault course which is only designed as a test of free movement of all joints and of adequate muscular power and not of stamina. The second test is a 5-mile march to be completed in one hour. It is felt that if these tests are satisfactorily performed the man is fit for discharge to unit or to I.R.T.D.

(2) *Specialists' Visits.* Arrangements have been made for specialists to visit the depot to see cases referred to them by O.C. Divisions. An orthopaedic specialist (Major B. Stimson, RAMC) visits twice weekly. Lt-Col. Capper, RAMC, and one surgical specialist visit once weekly and a psychiatrist visits once weekly. This method of referring cases has the following advantages over the previous one of sending cases back to hospital

- (a) There is a great saving in time and transport.
- (b) There is rapidity of decision and disposal. Medical Boards are held the day following the specialists' visit.
- (c) The man seen in the depot regards it as



part of the normal depot routine and not as a return to hospital.

- (d) The surgeons concerned are enabled to see the end results of treatment.

(3) *Pre-operative Treatment.* Cases for operation were collected from Western Italy and sent to the depot to await admission to hospital for operation. On arrival all hernias were placed in the hernia company and started exercises at once. Cases of internal derangement of the knee were sent to the rehabilitation wing for remedial exercises and for physical training. In this way, diagnosis of knee cases was facilitated, and in many cases passed through all stages of rehabilitation wing and depot training without breakdown, being returned to their units either in their present, or in a raised category. Major Stimson is satisfied that this preliminary training has greatly assisted the accurate diagnosis of knee conditions.

The progress of cases through the depot and attached units is shown in the accompanying diagram. Cases requiring physiotherapy are seen by the O.C. division and if considered suitable are treated in the depot remedial department by the normal staff. This department has improvised pulley apparatus, rowing machines and the usual remedial apparatus. Two corporal masseurs and a chiropodist are attached.

If the O.C. division considers the cases require more expert supervision they are referred to the O.C. rehabilitation wing for consultation, and are by him divided into three classes. The more serious cases are admitted to the beds of the wing. Those requiring special remedial measures are treated as outpatients in the wing treatment room which is equipped to give infra-red, radiant heat, faradism, galvanism and wax bath treatment. The third group are those considered to be fit for treatment in the Depot remedial department.

All cases are afterwards transferred to the appropriate depot grade and after passing through the grades are discharged in the normal way.

The hospital expansion takes post-operative cases of internal derangement of the knee and hernias, on discharge from general hospitals, for the first 10-14 days of treatment, after which knee cases are transferred to the rehabilitation wing and hernias to the depot hernia company.

All hernias go through the full course of rehabilitation as laid down in A.M.D. bulletin No. 11.

The rehabilitation of sick and wounded requires the following four main essentials:—

(1) *Occupation.* Men must be kept occupied throughout the day. In this Depot the morning is divided into two periods, one of physical training and one of lectures and demonstrations. The afternoon period until 1600 hours is occupied with organised games, route marches and on one afternoon massed P. T. In connection with this, it is essential, even if the depot is tented, to have adequate accommodation in buildings or in Romney huts for physical training and recreation in bad weather conditions.

(2) *Accommodation and feeding* must be the best available, and good surroundings and good food have a marked effect on the recovery of patients.

(3) *Recreation.* Every effort must be made to provide the maximum recreational facilities for off duty hours. The following facilities are available:—

- (a) *Library, Reading and Writing Room, and Information Room* with maps of all fronts kept up to date and illustrated by photographs.
- (b) *Games Room* for ping pong, darts and other indoor games.
- (c) *Theatre.* This Depot is fortunate in having a theatre seating 1,000, with an adequate stage. No evening of the week is without some form of entertainment. Two film shows and the Depot Concert Party show are run weekly, and E.N.S.A. and Welfare concerts, Tombolas, horse racing and other amusements fill in the week's programme.
- (d) *A Wine Bar* has been established which has had a marked effect in the reduction of numbers of patients going to the local wine shops, which not only serve bad wine at high prices, but are the rendezvous of the undesirable females of the district.
- (e) *A Salvation Army Canteen* providing tea and cakes which has an orchestra of four playing six nights a week.
- (f) *Day leave to Rome* is given within the limits laid down by the District authority.
- (g) *Swimming pools.* For summer months three large swimming pools are available.

(4) *Discipline.* It is necessary that the standard of discipline should be maintained at a high level. Only by this means will such crimes as absence without leave and selling of Government property be kept to a minimum.

With good discipline allied to adequate recreation the number of charges originating against soldiers remains extremely low.

Since the Depot opened in April 1943 nearly 20,000 patients have passed through and in the past four months the Depot has dealt with 5,021 cases. Of cases referred since October for cold surgery a total of 196 cases of hernia have received either operation or a satisfactory truss. In the same period 251 cases of internal derangement of the knee have been treated.

The average duration of stay of all cases has been 24 days. This figure is raised by long term cases of which examples are fractured scaphoids, internal derangements of knee and hernias.

Of other cases the times under treatment in the depot are as follows, based on the figures of the last quarter of 1944.

All types of wounds	-	-	-	20 days
Infections of skin (furunculosis etc.)	-	-	-	23 days
Infective hepatitis	-	-	-	21 days
Malaria	-	-	-	14 days
Diphtheria	-	-	-	24 days

A convalescent depot is faced with many administrative difficulties, not the least of which is a deplorably inadequate war establishment, but with an enthusiastic and efficient staff very valuable work can be done in the rehabilitation of the sick and wounded soldier.



After Col Briggs' paper the visiting surgeons were taken round the various departments of the Convalescent Depot.

This was followed by a series of short demonstrations:—

Major B. Stimson, RAMC — "*Selection of cases of Internal Derangement of the Knee for Operation*".

Demonstration of Post-Operative Knee Cases (Major Andrew, RAMC)

Lt.-Col. Bhatia, RAMC — "*Gunshot wounds of the Knee*".

Demonstration of Lt.-Col. Bhatia's cases.

Major P. Clarkson, RAMC — "*Skin Grafting*."

Demonstration of Major Clarkson's cases.

Lt.-Col. W. M. Capper, RAMC — "*A case of deep Femoral Thrombosis*."

Demonstration of case.

The visit ended with tea in the officers' mess.



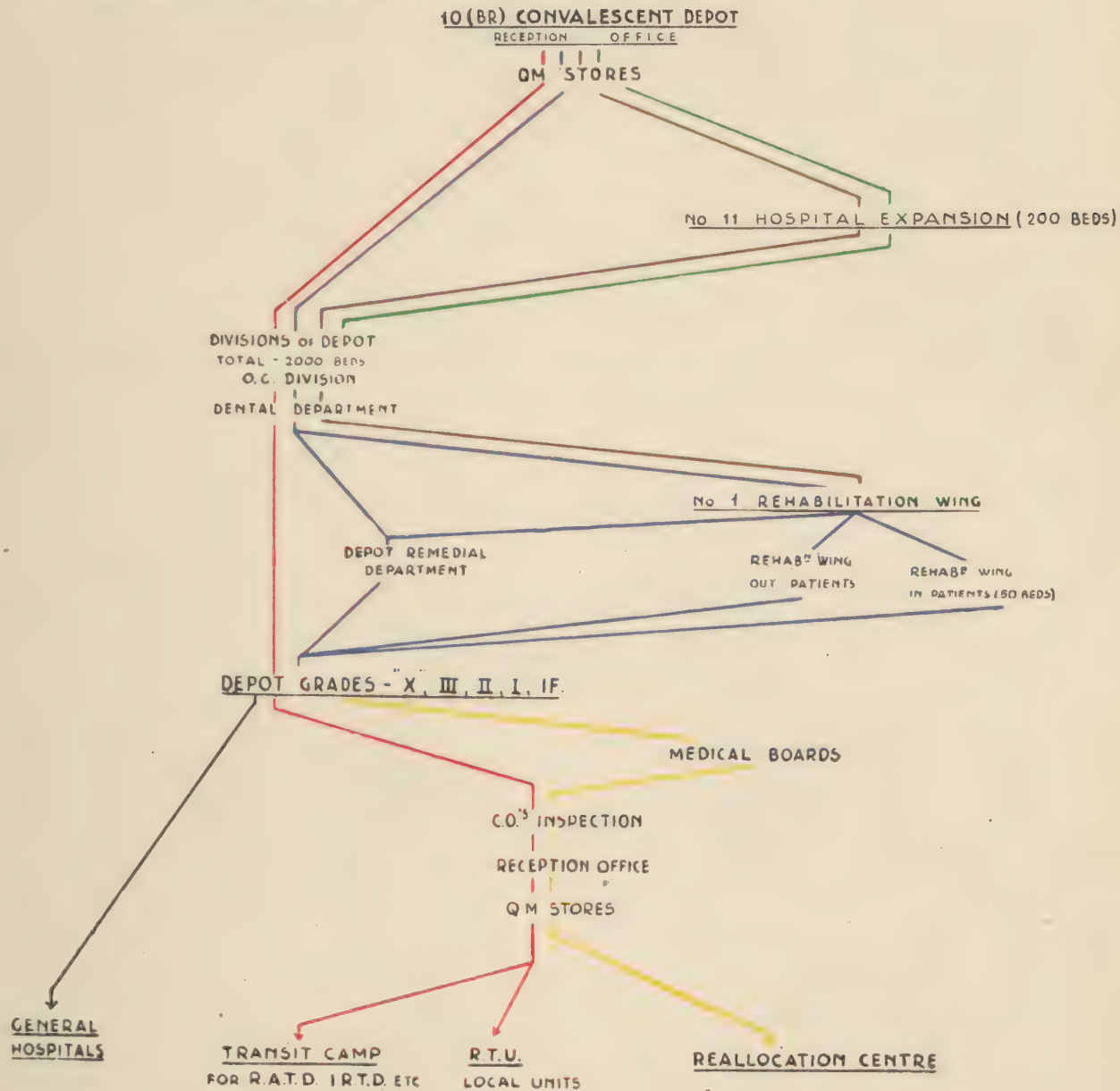


# ORGANISATION OF CONVALESCENT DEPOT

## Organization of 10 (Br) Convalescent Depot

With No. 1 Rehabilitation wing

And No. 11 Hospital expansion Attached



### LEGEND:

- Normal cases.
- Cases requiring physiotherapy.
- Postoperative cases (Idk & Hernia) discharged early from gen. hospitals for rehabilitation.
- Medical and minor surgical cases discharged early from hospital.
- Preoperative cases (Idk & Hernia) and cases referred back to hospitals.
- Cases recategorized and down graded.

Note: All transfers between departments are notified to and registered by the depot reception office.





Thursday, 15<sup>th</sup> February 1945

*Presiding:*

Major-General D. C. Monro, C.B.E., K.H.S.

*Consulting Surgeon to the Army*

Brigadier Edwards

We are glad to welcome two more distinguished visitors to this conference, Major-General Philip Mitchiner, from the Middle East, and Brigadier Naunton Morgan, from Paiforce. General Monro, Consulting Surgeon to the British Army has kindly consented to take the chair.

General Monro

It is a great pleasure for me to take the chair, and kick off in what in a minute or two should be a most interesting session. Before doing so, as a result of enquiries made yesterday, I'd like permission to ask a question, and get a show of hands. How many officers in this building who were entitled to a free issue of the Field Surgery Pocket Book have received a copy (*Show of hands*). It is quite obvious there has been a hold up in the distribution.





# MISSILE INJURIES OF THE URETHRA

by

Lt-Col. D. S. POOLE-WILSON, RAMC

## Introduction

The urethra is a small organ. In the male it is but eight inches long and about a centimetre in diameter. It is, however, a tortuous tube and surrounded by the most curious sphincter and erector mechanism in the body. It is therefore not surprising that battle injuries are rare, and that when they do occur they are often serious and frequently the prelude to a life of physical and mental anguish.

Just under a year ago, when the preparations for the Cassino battle were under way, Brigadier Edwards asked me to establish a Genito-Urinary Centre for the treatment of the injuries of the bladder and urethra. He, moreover, set me a more difficult task by asking me to frame some suggestions for the treatment of urethral injuries. My own experience of battle injuries of the urethra was not very great and in the literature most writing on the subject falls largely into the category of "armchair surgery" and does not bear the stamp of experience. It was therefore with some trepidation that I approached the problem.

The repair of the damaged urethra falls naturally into three stages:—

1. The deviation of the urine from the traumatised area.
2. The reconstruction of the urethra.
3. The maintenance of the urethral channel during healing and in later life.

The deviation of the urine can be easily accomplished by the performance of a suprapubic cystostomy, but the repair of the damaged urethra is often more difficult and errors made irretrievable. Prior to undertaking a repair it is therefore imperative to consider:—

1. Whether the operative surroundings facilitate good operative repair.
2. Whether the patient's general condition warrants a prolonged operation.
3. Whether the aftercare will be satisfactory.

If these conditions are not fulfilled it seemed to me advisable for forward surgeons to avoid carrying out complicated urethral repairs and to be content with performing a toilet of the wounds and a suprapubic cystostomy to divert the urine from the injured area. If a large perineal hæmatoma is present or if extravasation is suspected then a perineal incision may be made. Following this treatment the patient should be evacuated as rapidly as possible to the Base for further operative treatment.

This course was accordingly advised. Hard and fast rules seemed undesirable and in those difficult cases where an abdominal injury rendered retention of the patient in a forward area imperative, then the surgeon had to use his judgment as to whether more damage to the urethra would result from a difficult primary operation in an ill patient than from delay and repair at a later date.

This morning I propose to review the results of our treatment.

## The Patients and Their Injuries

Forty-four patients suffering from rupture of the urethra due to penetrating missiles have been admitted to this centre. All other varieties of traumatic rupture of the urethra have been excluded from this series. In almost all instances primary surgical operations had been carried out at field surgical units or casualty clearing stations and the patients arrived at varying periods from twenty-four hours after wounding. Many surgeons made great efforts to evacuate patients to the centre rapidly and as the front advanced northwards air transport proved a great boon.

The distribution of the lesions is shown in the following table:—

## Missile Ruptures of the Urethra

### 46 lesions in 44 Patients

Penile urethra	-	-	13.	} 46 Cases
Bulbous urethra	-	-	19.	
Posterior urethra	-	-	14.	

In two patients double ruptures of the urethra occurred. In the one the penile and posterior urethra showed separate and distinct lesions; in the other the bulbous and posterior urethra were separately damaged. The bladder was also injured on three occasions. In one patient a missile amputated the greater part of the penile urethra, perforated the posterior urethra and carried away a portion of the lateral wall of the bladder.

## The Projectile and its Course

The urethra has been wounded by almost every type of missile:—

Shell Wounds (H.E.)	-	-	19.	} 44 Patients
G.S.W. — Machine Gun	-	-	6.	
" — Automatic Rifle	-	-	5.	
" — Rifle or Revolver	-	-	2.	
Mortar Bomb or Grenade	-	-	5.	
Mine or Booby Trap	-	-	2.	
Unknown	-	-	5.	

Just under half of the patients were injured by through and through wounds. The remainder were penetrating injuries. The course of the projectile was most commonly either antero-posteriorly or postero-anteriorly. The urethra is relatively well protected from the sides and of the lateral injuries all but one were caused by bullets. It seems probable that small shell or mortar fragments fail to have the momentum necessary to carry them through the bony and muscular lateral walls of the pelvis and that the larger fragments cause such severe injuries that death supervenes. A bullet, however, traverses the side wall of the pelvis fairly easily and may pass completely through the body or come to rest in the pelvis.

The complications caused by missiles injuring the urethra are shown in the accompanying table:—

Perforation of the Peritoneal Cavity	-	-	4.
" of Bladder	-	-	3.
" of Rectum	-	-	9.

Colostomy for rectal, anal, or perineal injury - - - - -	18.
Orchidectomy - - - - -	19.
Partial atrophy testes - - - - -	2.
Fracture of Pelvis - - - - -	16.
Fracture of Femur - - - - -	4.
Fracture of Sacrum - - - - -	2.

Many of the patients also suffered from other severe wounds such as amputations and compound fractures.

### Review of Treatment

The patients on the whole travelled very well. In many instances the primary treatment had been confined to the debridement of wounds and the establishment of suprapubic drainage. Almost all of these patients reached this centre in good time and no cause for regret in advocating this policy was encountered. Forward surgeons also showed admirable judgment in their treatment of those patients, whom they were unable to evacuate at an early date. A few patients, who were held up in transit, had repairs performed at other hospitals and were subsequently sent on.

Following the admission of the patient an appraisal of the nature of his wounds and previous treatment was made from his notes and when necessary further X-ray examinations were made to determine the presence of foreign bodies or fractures of the pelvis. A complete survey of the patient was subsequently made in the theatre. At this examination it frequently became apparent that the injuries to the urethra were less severe than had appeared at the primary operation and that ruptures, which had been believed to be complete, were in fact partial. It was often impossible to pass an ordinary straight rubber catheter through the urethra but if a coude rubber catheter was used and if it was gently manipulated so that its passage was attempted with its point towards various aspects of the urethral wall, then frequently a site was found where it ran onwards into the bladder and demonstrated that the continuity of the urethra was not completely broken. When the lesions were of a relatively minor type any necessary repairs or sutures were carried out immediately. If the wounds, however, were severe, and extensive exploration or plastic repairs were necessary, then further operation was frequently deferred until a course of parenteral penicillin had been commenced and the patient generally prepared for a long and difficult operation.

### Extravasation

Only one case of extravasation of urine has been seen and this one was not of a very serious nature. Two factors account for this satisfactory position:—

1. Retention of urine normally follows an injury to the urethra. The patient is unable to micturate. It is only when the bladder, if unrelieved, finally overflows that extravasation occurs.

2. Forward surgeons have almost always carried out a suprapubic cystostomy long before this critical point is reached.

In the literature most accounts of extravasation of urine are based on records of flooding of the tissues with heavily infected urine following the rupture of a periurethral abscess behind a stricture. Sterile urine, such as is normally poured forth in a war wound, is not particularly irritating to the tissues. It is mainly when the wound becomes infected and

especially if the urine can not drain away that extravasation becomes dangerous. So far the gross extravasation, associated with sloughing and gangrene of the tissues and frequently gas-forming organisms, reported in the first world war of 1914-18, have not been seen.

### Ruptures of the Penile Urethra—13 Cases.

The following table shows the types of lesions encountered:—

Partial Ruptures - 7	{	glans penis - - - - -	2.
		glans and body of penis - - - - -	1.
		body of penis - - - - -	4.
Complete Ruptures 6	{	Traumatic amputations - - - - -	2.
		Others - - - - -	4.

The projectile most frequently traversed the penis in a transverse or slightly oblique direction but in two instances it entered the region of the glands, passed down the length of the penis injuring the urethra in its course and then travelled on into the perineum or pelvis. In only one instance did a foreign body lodge in the penis.

The partial ruptures were mainly caused by small penetrating missiles. Two of the three cases of injury to the glans and adjacent body of the penis required plastic repairs. One of the four patients suffering from a partial rupture of the body of the penis was treated with an in-dwelling catheter but this treatment was later abandoned and when continuity of the urethra had once been demonstrated no catheter was left in position and no further treatment given except the occasional passage of a sound to ensure that a stricture did not form.

Four of the six cases of completed rupture were complicated by considerable damage to the penis. In the two instances of traumatic amputation, the penis had been cut completely across about one inch from the pubis and the skin torn away from the remaining stump up to the level of the pubis. Both cases were complicated by severe wounds in the left groin and in one the posterior urethra and bladder were also injured. It was evident that if the remaining stump was not covered with skin gross retraction would occur and render the organ practically useless. In both patients other injuries rendered immediate grafting impossible and it was several weeks before the patients were fit for treatment. By this time considerable retraction had occurred. The stump of the penis was mobilised in each instance and covered by a skin flap cut from the scrotum. One case was completely successful and before returning to the United Kingdom he was able to micturate normally through the fly of his trousers. In the other patient, the flap was cut a little too narrow at its base and some terminal necrosis occurred. Owing to a change of hospitals, I had to leave this patient behind me but I am informed that he healed up more satisfactorily than had been anticipated. He has since been evacuated home, where a small skin graft has been applied to the remaining raw area. It must be stressed that if the length of the remaining stump of the penis, in cases similar to these; is to be maintained early plastic repair is essential.

Two of the completed ruptures of the urethra were complicated by gross penile damage. In one patient it was possible to pass a finger completely through the penis. This soldier was seen on the fourth day after injury and the wound was clean. The ends of the urethra were found, mobilised and



a complete suture performed around a catheter arranged for penicillin irrigation (see Penicillin). The corpora cavernosa penis were repaired as far as possible and the subcutaneous tissue and skin sutured. Complete healing, except for a minute sinus leaking about five drops of urine per act of micturition, was obtained. The other case of complete rupture was also treated by suture of the urethra and delayed primary suture with success.

The two remaining cases of complete rupture were fairly old injuries in two Yugo-Slav Partisans. They required complete excision of the strictures and suture of the urethra.

### Ruptures of the Bulbous Urethra

Further cases of rupture of the bulbous urethra have been observed and are classified as follows:—

Contusion bulbous urethra	-	3	} 19 Cases
Partial rupture	-	13	
Complete rupture	-	3	

Contusion of the urethra was diagnosed when following a wound in the region of the urethra retention and bleeding occurred but no difficulty was experienced in passing a catheter. In two of the three cases there were extensive groin and perineal wounds. In one of them the right corpus cavernosum penis had been partially destroyed and the urethra could be seen lying intact but bruised in the bottom of the wound. The wound was closed with penicillin irrigation in an attempt to stop the onset of infection and possible necrosis of the urethra. The treatment proved successful. At a later date an extensive plastic repair of the penis was performed.

Thirteen partial ruptures of the urethra were treated and were mainly caused by projectiles passing antero-posteriorly across the perineum but a few were due to mine and shell wounds, which entered the perineum from below. Eight cases required no operative treatment but in five repairs of the urethra were performed.

Three cases of complete rupture of the bulbous urethra have been treated. It has so far always been possible to mobilise the ends of the urethra sufficiently to bring them together and to obtain complete suture. One of these patients was of particular interest as half the scrotum had been carried away and the bulbous urethra and corpora cavernosa penis were completely divided. The distal portion of the penis remained attached by a dorso-lateral skin flap containing the dorsal arteries and veins of the penis. The distal portion appeared viable and after defining the structures in the divided ends complete sutures of the corpora cavernosa penis and the bulbous urethra were performed. Union occurred but a small fistulous track leading down to the suture line remained and will require closure.

The use of penicillin, both intramuscularly and by local urethral irrigation, has allowed closure of perineal wounds, which would otherwise have been left to granulate. Healing has thus been accelerated and there can be little doubt that the resulting decrease in scar tissue means less tendency to stricture formation.

### Rupture of the Prostatic-Membranous Urethra

Fourteen ruptures of the posterior urethra have been treated. The injuries may involve any portion of the urethra but for classification they may be grouped into (a) injuries involving the bladder neck and the proximal portion of the prostatic urethra,

(b) injuries to the body of the prostate, (c) injuries to the region of the membranous urethra. A catheter can seldom be passed in these patients and it is therefore impossible to divide them satisfactorily into partial and complete ruptures. There is, however, little doubt that in many the continuity of the urethra is not completely broken. The wounds of the membranous urethra are the most dangerous from the point of view of stricture formation but complete ruptures at the junction of the prostatic and membranous urethra with posterior dislocation of the prostate on the urogenital diaphragm, such as occur in severe traumatic fractures of the pelvis, are rare.

The rectum has been injured on five occasions but only one prostatico-rectal fistula has persisted and required separation and closure.

The danger of stricture formation in the region of the membranous urethra and the impossibility of treating this condition satisfactorily at a later date, has led me invariably to use an in-dwelling urethral catheter as a splint. It is probable that this is unnecessary in many wounds involving the bladder neck or body of the prostate, and that the rigidity of the remaining prostatic wall is sufficient to prevent the ends of the urethra getting out of alignment. Nevertheless the difficulty of estimating the exact extent of the wound and the seriousness of an unsuccessful outcome seem to make an in-dwelling catheter imperative.

Two methods have been used to introduce the rubber catheter. In the first method a finger is passed down into the posterior urethra and it is then frequently possible to guide the tip of a Lister's sound, which has been passed down the anterior urethra, into the bladder (5 cases). The distal end of a small rubber catheter is then slipped over the tip of the sound so that it grips it firmly and the catheter is drawn through the urethra by withdrawing the sound. In the more difficult cases, where the rupture is in the region of the membranous urethra, two Lister's sounds are used, the tip of one of which has been slightly hollowed out so as to form a cup in which the tip of the other may engage.

The female sound is passed through the internal urethral orifice and the plain one down the anterior urethra. The two sounds are gently manipulated until the points engage. These are then kept firmly together whilst the distal sound is slipped onward into the bladder. A rubber catheter is then attached to its tip and drawn back down the urethra. These methods have so far, always been successful and no perineal explorations have been necessary.

The in-dwelling catheter is held in position by a stitch through its tip, which is brought out alongside the suprapubic Malecot catheter and tied to a piece of rubber tubing on the abdominal wall. This technique also ensures that subsequent catheters can if necessary, be drawn through the urethra. The catheter is not really for use as a drain but as a urethral splint. Prior to introduction a piece of thread is tied around the catheter immediately distal to the eye. This prevents drainage down the catheter and allows of one less tube to be attached to a bottle during evacuation. If the catheter is not draining, it is also easier to keep the catheter and urethra sterile as the whole of the perineum and penis can be covered up in sterile dressings. This catheter is also frequently used for penicillin irrigation (see Penicillin).



The urethral splint is left in position for at least two weeks so as to ensure firm fixation of the ends of the urethra.

### Explosive Wounds of the Perineum

Four ruptures of the urethra were complicated by so-called "explosive wounds" of the perineum. In these cases a missile has passed either from the anterior abdominal wall or the buttocks down into the perineum and in emerging has burst this region wide open. The skin is torn away from the margin of the anus, which lies drawn up in the centre of the wound and surrounded by gaping perineal and buttock tissues. A wound six to eight inches in diameter may be present and appears out of all proportion to the size of the emerging missile.

These wounds are formidable, yet when carefully examined the damage is often less severe than was anticipated. A colostomy must be performed to divert the faeces. A careful repair of the urethra and rectum should then be carried out and delayed primary suture performed. If this is not done, the rectum remains drawn up and the tissues are fixed in malposition by fibrous tissue leaving an extensive and rigid wound, which is difficult to deal with by secondary suture.

### General Observations on Treatment

1. *Delayed Primary Suture.*—The principles of delayed primary suture hold for perineal wounds involving the urethra. It is most desirable to avoid large granulating wounds in the perineum as they render all the tissues rigid and in the event of a urethral repair being unsatisfactory make subsequent operations extremely difficult. Using parenteral and irrigation penicillin almost all perineal wounds have been closed. The impression has been formed that the urethra has healed with less fibrous tissue formation, that less scarring has occurred in the perineum and that osteo-myelitis of the pelvic bones has been avoided by covering over compound fractures of the ischium.

Fine instruments are essential for repairing the urethra. Suturing has been carried out with six—0 plain catgut.

2. *Localisation of Foreign Bodies in the Pelvis.*—With Field X-ray sets, it is often difficult to obtain good lateral pictures of the pelvis for the localisation of foreign bodies. Stereoscopic pictures have proved of great value and give a three dimensional picture of the position of a foreign body in the pelvis, which is difficult to reconstruct from antero-posterior and lateral views.

Occasionally a urethrogram may be extremely useful. A piece of shrapnel lying in the membranous urethra was localised exactly by this method and removed by a perineal approach.

3. *The Use of the Indwelling Catheter.*—At first an indwelling catheter was used fairly frequently to splint wounds of the penile and bulbous urethra. The presence of a foreign body in the urethra must however, retard healing to some extent and for wounds in these areas I have found myself relying more and more upon careful repair than upon an in-dwelling catheter.

For wounds of the posterior urethra the indwelling catheter forms an admirable splint. A small size is used (6-8E; 15 F) so as to permit free drainage down the urethra around it.

4. *Penicillin.*—Penicillin has been extensively used in this series of cases.

(a) *Parenteral Penicillin.*—This has been given (15,000 units 3 hourly for 5 days or even longer) when wounds have been extensive. It has also been my practice to commence a course of parenteral penicillin twenty-four hours prior to carrying out any extensive perineal sutures or plastic repairs on the urethra.

(b) *Irrigation Penicillin* has been used with considerable success in closing dirty perineal wounds. The irrigation tube has been introduced through a stab incision and 3.5 ccs. penicillin (250 units per cc.) gently instilled twice daily.

(c) *Urethral Application.*—It was felt that irrigation of the urethra with penicillin solution might reduce infection and prevent fibrosis. Two methods have been employed:—

(1) An indwelling catheter is fixed in position as previously described. Prior to introduction a piece of thread is tied around the catheter immediately distal to its eye, so as to prevent any flow of urine down the catheter. A second eye is then cut in the catheter distal to the ligature at whatever level it is desired to flush. Following fixation of the catheter in position irrigation penicillin (5-10 cc) is injected down the urethra twice daily and flushes the urethra.

(2) When a catheter is not in use the urethra has been irrigated with 5-10 ccs. irrigation penicillin using a urethral syringe. The solution is held in the urethra for 10 minutes with a urethral clip.

These two methods have been extensively used and have seemed of considerable value.

5. *After Treatment.*—In no form of surgery is good after treatment more important than in urology. Suprapubic tubes have been washed out daily and the moment there is any sign of obstruction or overflow they have been changed. Very large perineal dressings have been employed to keep wounds in this area uninfected. Too frequently one sees a small pad placed on the perineum and held in position with a flimsy T-bandage with the result that it comes adrift and the wound is exposed in the bed.

6. *Cessation of Suprapubic Drainage.*—No definite times can be laid down for the healing of urethral wounds and each case must be judged on its merits. The tendency is to remove suprapubic tubes too early. It has been my practice to continue suprapubic drainage until all perineal and urethral wounds are completely healed and no urine should pass down the urethra until this time is reached. Too often one reads a happy note "urine passed down urethra" and the subsequent history shows that this was taken to indicate urethral healing and time for the removal of the suprapubic tube. More often it indicates that the suprapubic tube was blocked.

When the time is ripe to try normal micturition a spigot is placed in the suprapubic tube and the patient encouraged to pass urine through his urethra. If any leakage from perineal or penile wounds occurs then suprapubic drainage must be continued, but if after a few days all wounds remain absolutely dry then the suprapubic catheter is removed and the wound allowed to heal. It is surprising how little urine leaks through the healing suprapubic wound (the patient has already learnt to micturate) and indwelling catheters have not been used at this stage as it has appeared unwise to risk starting even the mildest urethritis.



## Results

The following table shows the results so far obtained.

### *Patients—44.*

1. Death - - - - -	1
2. Returned to duty (Cat. B.1) - - -	10
3. Evacuated to U.K. Micturation normal - - - -	19
4. Evacuated to U.K. Minute urethral sinus present -	3
5. Evacuated to U.K. with suprapubic tube in position - - - -	4
6. Remain under treatment - - -	7
	44

Until the commencement of this year no patient was evacuated home until normal micturition had been regained. Hospital movements then made it essential to evacuate four patients home with suprapubic tubes in position. It is expected, however, that these four patients (with possibly one exception) will regain normal micturition.

The patients returned to duty have been given a "Urethral Dilatation Card" with the type of stricture, the size and type of sounds recommended and the date for the next treatment clearly indicated. It is hoped that surgeons will help these men by keeping their cards up to date.

Of the late results (stricture, chordee, sterility) it is too early to judge but it is hoped to follow up all of these patients and to obtain a completed record of their subsequent disabilities.

## Conclusion

I cannot conclude this paper without thanking Brigadier Edwards for his great help and interest in establishing the Genito-Urinary Centre and you, gentlemen, for sending your patients to me. I wish also to place on record my gratitude to a very loyal and patient band of General Duty Officers, Sisters and Orderlies who have striven quietly and unseen to help in the recovery of these patients.

## Discussion

### *General Monro*

I am sure everything has been made quite clear without any remarks from me. I think we can say now, in the absence of any challenge from Col. Churchill, that previous writers on this subject have approached it rather from the armchair. In Col. Poole-Wilson's contribution, we have had a definite breakaway from history. Col. Poole-Wilson asks whether those who were in the last war remember what extravasation of urine looked like in these wounds. I have seen them, but I do not remember if they differed much from the civilian ones. I should imagine that they were not as bad as they looked. I was reminded when Col. Poole-Wilson was describing his endeavour to cover up remains of the stump of the penis of a somewhat unique experience we had in Russia two years ago in July, when a Russian surgeon showed us his efforts at reconstruction of the penis, making use of what remained of the scrotum to form a core of the urethra by plastic measures. He proceeded to bring down a flap from the costal margin including some cartilage of the last rib. He brought that down and stitched it to the lower half of the reconstructed penis, and in five or six weeks

managed to produce a banana-like object in the pubic region and managed to get a urethral opening. He claimed that this satisfied the man, improved morale, and in some cases even satisfied the wife! With reference to Col. Poole-Wilson's equipment difficulties, I should like to say that any requests for instruments which you fellows may put up through the normal channels, and which are referred to me, will generally be supplied, if they can be produced.

### *Lt-Col. Moore*

I would like to congratulate Col. Poole-Wilson on his good fortune to have the opportunity of dealing with so many of these cases, and also on the lucid way in which he has put before us the lessons he has learned from that experience. I have had a very much more limited experience of war injuries of the urethra and bladder than he, but there are one or two points which occurred to me which I think should be discussed at this meeting. Firstly, in my experience, injuries of the bladder and urethra are almost always complicated. It is very unusual to get a gunshot injury which is not complicated and not difficult to treat. In the primary treatment of both lesions the institution of adequate suprapubic drainage is essential. I think in the performance of that simple operation points of technique should be carefully observed. It is essential that the suprapubic should be high and that the track should be oblique. In cases where the suprapubic is carried out just above the pubis, months later when the urethral injury is healed, the suprapubic does not heal no matter how long you use the indwelling catheter, because the suprapubic sinus becomes adherent. When it is in the lower part of the bladder, and adherent to the back of the pubis, it is very difficult to excise the sinus and completely close the bladder. I agree with Col. Poole-Wilson that the injuries of the urethra are usually partial, and in the primary treatment there is little to do but to drain the bladder. The perineum should not be drained unless there is a very large hæmatoma. In cases where the injury to the urethra is below the pelvic diaphragm, there is, in my opinion, no need to carry out any primary treatment of the urethra, because the two ends are fixed and do not retract, and can be very easily and satisfactorily closed later in ten days or even three weeks. I believe, however, that in the cases where the injury to the urethra is as Col. Poole-Wilson said, above the pelvic diaphragm, if an ordinary catheter cannot be passed at the time, the suggestion is that the lesion is probably complete, because when you have a complete lesion in that position bladder and prostate fall back, and there is quite considerable separation between the two ends. In these cases it is absolutely essential at the primary suprapubic to pass the urethral catheter by the method which you saw Col. Poole-Wilson demonstrate. Firstly splint the urethra and secondly hold the two ends in the right position, because if such a case is left to be done at a later operation it is extremely difficult indeed to identify the two ends of the urethra because of a mass of hard fibrous tissue, and having identified the two ends, to get them to come together. The suprapubic tube inserted at the primary operation is usually taken out too soon. I have seen two or three cases with wounds through the bladder, in which the suprapubic tube was removed within 14 days of the patient first passing some urine. Actually we must remember that apart from



the anterior wound in the bladder there is also a wound in the posterior wall, and in one case I saw, when the patient was passing urine per urethram, some was also passing through the hip joint and escaping through a wound in the abdomen. In these cases it is important to prolong suprapubic drainage until the posterior wound of the bladder has healed. It is also best to have some method of suprapubic suction. Another point in their treatment which has been overlooked is arthritis of the hip-joint, which required fixation in plaster. Cases are seen in which the sinus from the bladder communicates with the pelvic fracture or hip joint. These are extremely difficult to treat. The patients are very ill and very toxic, and you are often at your wits end to know what to do with them. I have on two occasions explored the bladder. A method of fixation of such cases which I have also found to be of value when they are apt to get plaster sores, is just to include both legs in plaster and have a cross bar between them. This is generally satisfactory. Complete wounds of the urethra will need later suture, but I think I agree with Col. Poole-Wilson that the majority of these cases are partial wounds, and do not need either a urethral catheter or subsequent operation. I was interested to hear Col. Poole-Wilson mention that he was using penicillin. I personally have never used penicillin in cases of injury to the genito-urinary tract. Perhaps I should have, but on technical grounds I think it would be rather an expensive diet for the bacillus coli but if it does good, then theory does not matter. One other point—in suturing the bladder and in doing a suprapubic for any reason, I believe it is important to use absorbent catgut. I remember very well an officer who had suffered an injury to the urethra in which we had to do a secondary operation. We had a good result. It all healed up, then he began to complain of pain at the tip of the penis after micturition. Cystoscopy showed a most beautiful calculus formed around the unabsorbed suture. I have already taken up too much time and would like to thank Col. Poole-Wilson for his most interesting paper.

#### *Major Blackburn*

I was not expecting to inflict anything on you today. I think injuries to the bladder and urethra at our end of the picture are, relatively speaking, easy. It is the associated wounds which Col. Poole-Wilson described so well, particularly the large extensive wound of the perineum that cause us more anxiety than the urethral one itself. General Monro mentioned just now that these injuries in the last war were sometimes associated with gas gangrene. Gas gangrene will be discussed to-morrow. I think it is a real danger in these extensive wounds of the buttock. I had a recent case in which the blood loss and damage to the buttock muscle seemed to be a difficulty I could not get over, but the injury to the urethra was one I could shelve, or send on to base. Occasionally in cases with urethral and rectal damage one should consider removal of the coccyx. That does not fall strictly into injuries of the urethra, but injuries of the urethra alone are extremely uncommon. On one occasion I have removed the coccyx and left the perineal wound wide open. It was before the days of penicillin, and the resultant wound was extremely dirty. The last one I am glad to say was a great deal better, and I believe it was due to the administration of a course of parenteral penicillin. In that particular patient, having dealt

with the buttock wound, it was obviously my duty to get the patient to Col. Poole-Wilson at the first possible opportunity, and he illustrates one point I think every forward surgeon may have found, and that is the extreme difficulty of ascertaining the nature of the damage to the urethra in this and in similar cases. It does not really matter, I submit, whether these lesions are partial or complete. It is quite obvious that the patient does not require detailed examination and investigation at the primary operation because repair does not come into the question at that level, and any exploration is hazardous. I made it a practice in the few cases I have seen to do a cystotomy, and to pay little attention to the detailed nature of the urethral wound because of the lengthy anaesthesia required. As Col. Moore has observed, the importance of doing adequate cystotomy is quite enough to be going on with. One last point, the question of associated bone injuries which, of course, give some difficulty. I always wonder how to send down cases of fracture of the pelvis with or without a cystotomy. We all wonder how to send down cases of fracture of the spine with a cystotomy. If someone can answer that question for me, I and many other people would be grateful.

#### *Lt-Col. d'Abreu*

I should like to ask Col. Poole-Wilson one point about intra-pelvic rupture of the urethra which we see in "jeep" accidents. In the course of the war I have dealt with 18 such cases, a small series, perhaps about three a year. I want to know if Col. Wilson thinks that correction of the urethra should be done early. I have always thought myself it was an urgent matter, and I am surprised in talking to many surgeons that they are not perhaps acquainted with the very classical features of this injury. One thing I have noticed is that extravasation is exceptional. When the suprapubic is being made, the first feature I think which disturbs the inexperienced surgeon is the large amount of blood in the tissues, and I would advise these not to be disheartened. The surgeon's duty is to open the bladder rapidly and carry out the measure Col. Wilson has described. The whole operation is easy, and can be done quickly. I think if these cases are left and not corrected, the result may be an extremely difficult one to treat. They may be left with a suprapubic sinus for all time. Correction, as Col. Wilson points out, is easy. The method I use is not as good as he has adopted. I use two silver catheters with holes in them. The details you all know. One question I would like to ask is whether we should not encourage forward surgeons meeting with this injury to carry out correction of this poster or displacement at the earliest possible moment.

#### *Lt-Col. Poole-Wilson (Replying)*

I must apologise if my remarks seem to cast aspersions on supplies from the War Office. We have some grumbles, but, on the other hand, we have on many occasions to return great thanks. I must thank the War Office through the efforts of Brigadier Edwards for getting me two huts in which to work. We have got many things, but, on the other hand, there are some little things we do feel strongly we want. Col. Moore has brought up several points. We both come from the same city, and I agree with all he says, so all is well. So far as suprapubic drainage goes, I have been very pleased with the level at which most of them have been done; they



have on the whole been done high. Nobody has gone above the umbilicus, though some have got very near it! I might also add that I have been at times a little surprised at some of my own suprapubics. I thought I had brought them out pretty high, but one finds that in time they appear to have gone very low. I think I can answer the questions of Col. Moore and Col. d'Abreu together. Actually I was speaking this morning of missile wounds of the urethra, and in these wounds I have not yet encountered dislocation of the prostate on the membranous urethra. That may have just been luck, but I have not yet met true dislocation in gunshot wounds. If we include traumatic injuries with fracture of the pelvis such as occur in motor accidents, I have had quite a few of these, and several in which the membranous urethra has been definitely torn but not grossly displaced. I agree with Col. d'Abreu entirely; if one is faced with a situation where one has the opportunity for doing these things well and has the right instruments, I think there is no time like the first operation for dealing with a dislocation of the prostate on the pelvic diaphragm. On the other hand, I do not think any damage, or at least very little, will result from doing the suprapubic and getting them back, if the second operation is done within one week.

If you leave them longer than that, these certainly become hopeless. On the whole, I think forward surgeons have realised that, and no disasters as yet have come down. I would put it down that if facilities are good I would have no hesitation in doing what Col. d'Abreu says, and put in a catheter and get the urethral splint in position at the first opportunity. The question of penicillin arose, and it is not that I think that I am killing the B. Coli with penicillin, but that many of these wounds are just ordinary infected war wounds and full of other organisms. I do think that it has been of great assistance and healing has occurred where otherwise it would not have done, and I have sewn up perineal wounds which in the pre-penicillin era I would not have dared to touch. On the question of catgut and fine instruments, I can only agree with Col. Moore in using for urethral wounds only the finest catgut, and, in addition, if you want to do good work, fine instruments are essential. Major Blackburn has raised the question of immobilising the fractured pelvis. It is a difficult problem, and I think that if they are fit to travel they should have nothing but a tight binder around the pelvis. As for a plaster of paris cast, I certainly have no use for it. I think I have answered all the questions, and I must apologise for trying your patience.

## BURNS

by

Major R.V. BATTLE, RAMC

Our two great interests in the treatment of burns are:

- (1) The preservation of life.
- (2) The maintenance and restoration of function of those parts of the individual that are affected.

In order to preserve life, we have to appreciate that the causes of death are many and various:—

- A. The severity of the burn. It is only too often forgotten, as in the treatment of wounds, that some burns are lethal.
- B. There are the entities which we understand as secondary shock, the toxæmia of burns, and the cachexia of burns.
- C. Then we have the superimposed strain of travel and anaesthesia to consider.
- D. Finally, associated injuries may bring a fatal termination — for example, blast effects of the lungs, as seen quite often in the battle burns of tank crews.

A. The severity of a burn must be considered in terms of depth and of surface area.

(i) *Depth*. — The degrees of burning have recently been greatly simplified from the six degrees of Dupuytren to the modern classification of partial and total epithelial loss. However, the old classification is more commonly understood, and I will refer today to burns of the second and third degree. The former without skin loss and thus carrying a good

prognosis, and the latter with skin loss and carrying a more doubtful prognosis. As a plastic surgeon it is naturally more with the latter that I am concerned.

(ii) *Extent*. — Patients have survived with burns involving 70% of the body area. A burn involving more than 10% is a serious burn, one of 20% - 30% may often prove lethal. Note that the hand in total area represents as much as 5% of the body surface. One aspect of the hand, however, represents 1% of this total area, and this figure acts as a useful guide in assessing the severity of a burn in terms of its involvement of surface area.

### B. Secondary Shock.

The syndrome of secondary shock is due to a decrease in the volume of the circulating blood, and is characterised by a hæmo-concentration with which you are all familiar. This concentration is caused by loss of plasma to the tissues more rapidly than it can be dealt with, and clinical œdema is always present with it. There is perhaps some doubt on whether all the circulatory loss occurs locally, or whether there is an increased permeability of the capillaries as a whole throughout the body.

The accepted treatment of this condition consists in the giving of plasma parenterally with a control, if possible, from estimations of the hæmoglobin — anything from 2 to 8 litres of plasma being required. Large doses of opium or morphine, together with oxygen in the presence of cyanosis, and possibly the tight pressure bandaging of the effected part must all be considered in the treatment.

There are as well, changes in the blood chemistry in the secondary shock of burns, which I feel certain, will be dealt with by Capt. Sturgis later this morning in his paper on metabolism.

*The Toxæmia of Burns* is an acute condition, but being often masked by secondary shock, it may not at first be spotted. It occurs most commonly between the 3rd and 6th days after injury, bringing with it a sharp rise in temperature and a steady rise in pulse rate. To quote from Matthews "The signs of azotæmia appear, mental clarity gives way to confusion, and vomiting begins. The urine becomes scanty and of high specific gravity, containing albumen and red blood cells. The blood urea rises to around 100 m. gms %. At this stage, jaundice may appear, when coma and death are to be expected within a short time."

The aetiology of this condition is most obscure, and several theories have been brought forward to account for it.

(1) Tannic acid, which in the past received so much credit for its action both in secondary shock and in this very toxæmia, has been suspected of contributing towards it. It has been suggested that tannates absorbed from the coagulum are the causative agents of the toxæmia.

(2) A bacterial toxin may be responsible, and the condition may be attributable to organisms on the burned surfaces.

(3) Some specific non-bacterial toxin may be produced at the site of the burn and circulated in the blood stream. Wilson observed the constant occurrence of severe necrosis of the central zone of the hepatic lobules in 65 cases of toxæmia.

I believe that the greater proportion of deaths in burns seen in the forward areas are associated with toxæmia.

The patient who is or has recently been under the influence of this condition is the one who travels badly. Similarly, the patient who, having recovered from this condition and who has sustained liver and renal damage, is the one who dies after administration of pentothal in full doses or prolonged anaesthesia of any kind.

Unfortunately the aetiology of the condition is so obscure that it is impossible to give a line of active treatment. The treatment is still prophylactic. In the forward areas severe burns of more than four days standing are not evacuated for at least a further week. At the base we never employ pentothal on a burn's case except in minimal doses, and then only if we cannot get nitrous oxide, or if the face is too severely burned to bear a mask.

*The Toxic Cachexia of Burns.* — This is a condition that develops from about the tenth day after burning, and which would appear to be associated with the separation or non-separation of sloughs. The clinical features are chiefly a fairly rapid deterioration in general condition, and can be detected by a sudden lowering of morale, increasing fatigue, and intolerance of the normal treatment routine — whether the last named be a dressing or merely an irrigation. The pulse rate and temperature creep up and remain up. A secondary anaemia is always present, and is characteristic. The hæmoglobin level may drop quite rapidly to the 50% mark, and the administration of whole blood is the first step in the treatment. If a rapid improvement does not take place, it is, to my mind, a direct indication for the removal of sloughs by surgical means.

Now for the maintenance and restoration of function.

*Burns of the Hand.* — There is little skin in the hand to spare. The loss of a small area of skin may lead to a scar contracture and consequently to impairment of function. It should also be remembered that skin loss is more difficult to replace efficiently in the hand than it is in any other region of the body — particularly in the palm and on the palmar aspects of the fingers.

Certain structures in the hand, being placed superficially, are very poorly protected by nature from the effects of heat, and their damage may lead to crippling results. For example: (a) over the knuckles, the extensor tendons very readily become exposed with subsequent sloughing and separation: (b) the extensor expansions over the dorsum of the inter-phalangeal joints are in a similar superficial and vulnerable position. Penetration of these joints is unfortunately only too common. Infection, arthritis, and possibly complete disorganisation, may follow upon a burn of little more than just third degree.

Circumferential burns of the fingers also carry a bad prognosis. The contraction of the granulating area in such a burn, or contraction of the coagulum obtained during treatment with one of the dyes or tanning agents, may lead to the loss of a finger from ischaemia.

There is the danger, shared also by the foot, that with loss of skin along the contiguous margins of the digits, adherence of adjacent granulations may lead to webbing.

Nowhere is the stiffness of a joint secondary to prolonged splinting seen more clearly than in the hand. A normal hand, if splinted wrongly for any period, tends to become stiff in this wrong position. For instance, stiff straight fingers will result if these are splinted in extension. A stiff wrist with considerable loss of power in the hand will result if that wrist is splinted in flexion.

With a damaged hand, under the same conditions, appalling results may follow prolonged or wrongful splinting. The "frozen" hand, as it has come to be called, is often more the result of bad treatment than it is of a severe burn.

### Principles of treatment

*Prevention of Infection.* — There is no doubt that a superficial burn can be very readily converted by infection into a deep one. Skin loss may result from infection reaching such a burn, anywhere during the early treatment. Similarly in a burn which is partly of second and partly of third degree — the infection may vastly increase the final area of skin loss.

The prevention of infection becomes the first and most important principle in the treatment of burns anywhere. First aid treatment of the affected part should be directed to that end. (As an excellent example of this, the R.A.F. First Aid Kit was passed round.) A rigid surgical technique must be observed throughout treatment, and not only at the first dressing and debridement. Dressing and baths must be done by trained personnel with all possible precautions against cross infection.

*The Maintenance of Function.* — Can function best be maintained, and deformity prevented, by a policy of "rest", or by one of "movement"? Firstly,



let it be clearly understood that by "rest" only one position of rest can be contemplated for the hand. This position is one of slight dorsiflexion at the wrist, 60% flexion at the metacarpophalangeal joints 45° at the interphalangeal joints, and with the thumb in opposition. This position is known as "the position of function". This is the position in which a hand should always be splinted (if at all) and from which a hand can regain its maximum function in the shortest possible time, irrespective of the severity of the lesion present.

It has been claimed that good results follow from the immobilisation of burns of the hand in such a position in plaster of paris. Elevation of the limb to minimise oedema is of course necessary, but apparently no permanent stiffness of joints follows the immobilisation of the wrists and fingers for periods of three or even four weeks.

I have no experience of this treatment and should particularly like this point to be discussed. I have seen many hands immobilised in the wrong position for short periods of time and then the results have been poor. Such things as coagulation therapy, wrongful or tight cramping dressings are still seen in the C.M.F., and increase the ultimate hospitalisation with even quite superficial burns.

McIndoe in 1940 emphasised a need for maintaining active movement in the burnt hand. In most British units that specialise in the treatment of burns, attention is concentrated on getting the patient to move his hand from the earliest possible moment, so long as organic destruction or oedema do not interfere with the active adoption by the patient of the position of optimum function.

Indications for splinting are as follows:—

(a) Oedema of the dorsum of the hand limiting dorsiflexion of the wrist. In the early stages of treatment a small cock-up splint, either of light metal or of plaster, should be applied. If oedema does not rapidly subside, then suspension of the hand above the shoulder level will materially assist. As soon as the power of active dorsiflexion returns, then splinting can be discontinued.

(b) The inability to maintain the position of optimum function that results from organic damage to joints and tendons. If movement is persisted in face of these conditions disorganisation may well result, and severe damage to joints may prejudice the ultimate function of the hand. The mere exposure of an extensor tendon over the metacarpophalangeal joint is not an indication to splint unless at the same time the power of extension at that joint is impaired.

(c) The really severely burnt and disorganised hand should be completely immobilised in plaster of paris for a period up to three weeks. In this time early cover of granulations has been obtained for exposed structures, and these should readily take a graft.

### Restoration of Function

*Repair of Tissue Damage.* — Skin loss should be replaced as early as possible during treatment. As soon as all sloughs have separated a clean granulating area is presented, and as healing begins from the edges of this area, contraction starts and movements become slowly and progressively impaired. In the hand it pays quite well to graft even small areas, particularly in the palms. Even with tendons exposed a free graft will accelerate healing.

In some severe burns, particularly those combined with crushing, there is a temptation to condemn a finger or part of a finger. As in other branches of surgery, extreme conservation must be practised in the hand. It is never possible to say in the early stages of a burn just how deeply the effect of that burn has penetrated, or to prophesy on the end result, and to give a prognosis.

Electric burns of the hand sometimes present a localised area, well demarcated and clearly defined, that will allow of immediate excision and grafting either by means of a free graft or if tendons are exposed, with a direct flap.

*Correction of Deformity.* — We need not dwell on the important principle of the correction of deformity, but only on the prevention of this deformity, as the more complicated cases return to the U.K.

*Physiotherapy.* — For those who practise continuous active movement of the burnt hand, the help of a physiotherapist is of the utmost importance. In the early stages of a burn, daily encouragement is, and must be, practised almost to the point of bullying. After healing has occurred, either naturally or through the surgical provision of a skin covering, heat, movements, exercises etc., are required to bring that hand back to the normal. In this connection wax baths are the most effective single weapon in restoring circulation and movement. Their omission from the armamentarium of the military physiotherapist can only be deplored.

### Problems of Army compared with those in R.A.F. and Royal Navy

In assessing methods of treatment suitable for burns of the hand occurring amongst military personnel, it is as well to consider our problem as contrasted with that of the other services.

The Royal Air Force has had to contend with a constant run of burns that are severe not only in depth but in extent also. The Air Force burn of the hand is commonly deep and often circumferential at the wrist and fingers. Consequently it was found that coagulation therapy was not satisfactory. Immobilisation of the hand, except of course for the indications mentioned above was found to be detrimental. This service therefore adopted and became the masters of the open treatment with brine baths. As the problem of evacuation was not with them a serious one, they were able to set up a number of specially equipped and specially manned burns centres.

The only danger of the open treatment has been cross-infection that almost invariably accompanies multiple dressings. Particularly tiresome has been the sulphanilamide resistant hæmolytic streptococcus. This organism by its proteolytic action prevents successful free grafting. Now that penicillin is available and so long as no penicillin resistant strains are evolved, the "bath and dressing" technique for burns can hardly be improved upon, particularly if the Royal Air Force continues to operate mainly from English bases.

The problem of the Royal Navy presents itself somewhat differently. Instead of a steady trickle of burns cases, these tend to come in batches. If a ship is struck, a large number of burn casualties may result and accumulate in the sick bay in a very short space of time. The facilities tend to be overwhelmed, and in consequence their method of dealing with early cases must be one capable of



rapid application. Furthermore, early evacuation to a base centre may not only be slow, it may prove to be quite impossible. Thus the early treatment must be more than a first aid measure — it must be definitive. The big specialised centre is not of the same value in this service as it is with the Royal Air Force.

Realising these facts, Bunyan, a dental officer in the Royal Navy, designed, in co-operation with a manufacturer — Stannard — the envelope that bears their names. Electrolytically prepared sodium hypochlorite was chosen by them as the irrigating fluid, not only because of its high available chlorine content, but largely because it could be readily prepared from sea water.

The Army's problem in the C.M.F. is somewhere between the other two services. Firstly, burns occur in a steady stream the whole time. Those reaching me have been for the greater part accidental, and the result of lighting fires for cooking or for brewing-up, with petrol or paraffin. Only a few of these, or of the battle casualty burns, have approached in severity those commonly seen during Dunkirk or the Battle of Britain, and still encountered by the Royal Air Force today. Evacuation is mostly good. A soldier with a severe burn, in the forward area of Eastern Italy, can reach a specially designated hospital within a few hours. If fit for further travel, he can go by air to a burns centre at the base with two hours of aeroplane and a further hour and a half of ambulance.

However, the severely burnt patient does not travel well, and this fact coupled with the delay in obtaining special equipment, renders impracticable the establishment in Italy of lavishly equipped burns centres. Moreover, the front line can be expected to move at any time — the base moving also, sooner or later.

The open treatment of burns by saline baths and repeated dressings is a considerably more hazardous business in the C.M.F. than at home. The hospitals here are often in improvised buildings — schools, barracks, etc. Flyproofing is rarely perfect. Dust and flies abound in the hot season. Against this can be placed the comparative rarity of the hæmolytic streptococcus, but I still feel that the stage is set for a really dangerous cross infection epidemic in burns wards with any system of repeated dressings.

### Types of Treatment Available

It would seem that there are three lines of treatment open to us in the C.M.F. for the treatment of burns of the hand. I do not even mention coagulation therapy as it has always been so strongly condemned in this war and is forbidden by Medical Administrative Instructions.

- (a) Plaster technique or closed immobilisation.
- (b) Sulph. powder or penicillin with vaseline gauze - open mobilisation.
- (c) Bunyan Stannard envelopes or closed mobilisation.
- (a) *Plaster Technique.*—Plaster has been used a great deal at Oxford and found to be satisfactory. After a careful debridement, the limb is wrapped in dry bandage and a plaster is applied with the hand and wrist in the position of function. The plaster employed must be of the absorbent type, and home made bandages employed rather than those of the proprietary brands that are available. As little padd-

ing only is employed, the wrist must be elevated to control œdema. A loop for this purpose is incorporated distally. If burns are particularly extensive or deep, the elbow is also included in the plaster with plenty of padding over the elbow prominences and round the upper arm.

The technique is well worthy of discussion. In its favour it can be said that it allows a patient to travel comfortably, that no dressings are required, and that the chances of cross infection are slight. Against it there are the dangers of œdema developing under the plaster so that the patient cannot be evacuated for the first few days whilst the arm is suspended.

Immobilisation is unlikely to be as effective in restoring function as is movement. To say that such a treatment is suitable for the simple burn of civilian life is to run into a trap that is better avoided. Who is to say dogmatically at the first treatment of a burn exactly to what depth it penetrates?

*Penicillin and Vaseline Gauze Dressings.*—The treatment of hand burns with sulphonamide or penicillin and sulphonamide powder, together with vaseline gauze and dry dressings is universally employed in the forward areas. Opinions clearly differ as to the initial treatment. In some cases all blisters are left untouched, in others a careful debridement is effected—it appears to matter little so long as the cleansing with soap and water and/or saline is done in an operating theatre with full surgical precautions. However, it should be borne in mind that C. P. G. Wakeley (1940) found fluid in blisters sterile at first, but almost invariably cultured hæm streps after 24 hours. It is advisable to pierce blisters and so evacuate the fluid, although collapsed skin may still be left as an adequate dressing in second-degree burns. Some degree of infection is almost certain in third-degree burns, and therefore in mixed burns blister skin should be well cut away to prevent pocketing. Intravenous morphia or alopon and scopolamine are almost certainly better than the administration of a general anaesthetic for the comfortable performance of this operation, but my impression is that general anaesthesia is preferred when there is a rush on.

I would like to mention the following faults in the accomplishment of this treatment seen when the patient reaches us at the base:—

- (1) The importance of movements is rather ignored. Fingers, although separated by vaseline gauze, still are wrapped together, movement thereby being inhibited. In some cases the fingers have been wrongly splinted in plaster either with extension at the metacarpo phalangeal joints or with the thumb and fingers flat in the same plane. It is important to cut away the cock-up splint round the thenar eminence to allow dropping of the first metacarpal into opposition.
- (2) The initial splinting during the first three to four days, when œdema is at its maximum, has been neglected.
- (3) Too little attention has been paid to movement of the shoulders and elbows, which in consequence become increasingly stiff.
- (4) In cases reaching No. 1 M.F.U. from other hospitals there has been far too much reliance on general anaesthesia—probably because of the little time available to the surgeons concerned.



This has meant (a) that the patient has become anaesthetic conscious and is unduly worried as his dressing is done under omnopon and scopolamine only, or without the aid of any drug (b) that he has not had the opportunity to move his fingers without the restriction of dressings, and (c) that the dressings have usually been whipped off hurriedly with considerable trauma to any healing process present up to that time.

The logical after-treatment at the base of a hand treated in this way with penicillin and vaseline gauze is a continuation of the same policy, but with every encouragement to movement. For full movement, freedom from dressings is essential, and repeated redressings after controlled exercises are necessary.

The danger of this treatment lies in that the more severely injured hand, and therefore the most susceptible to infection, is also most exposed by repeated dressings.

*Bunyan Stannard Envelopes.*—I have found the Bunyan-Stannard envelopes to give me the most satisfaction in the treatment of hand burns out here in the C.M.F. I believe that there are many surgeons here who have tried and condemned them because they have neglected some important point in the technique of using these envelopes, and so I am entering into some detail on their use and hope that I am not repeating information that is common knowledge to all present.

The envelope I show here is one of the early pattern with a seal at its neck. It has the disadvantage that it is difficult to sterilise. The later type is of the "tie on" variety and can be autoclaved. This is the "shortarm" type of bag for wounds of the hand and wrist. If the bag is applied at the time of the initial treatment the burnt area is cleaned under light anaesthesia or with morphia or alopon and scopolamine. The cleansing can be with soap and water and saline or by wiping down under a stream of strong Dakin's or Milton. A place is selected for the seal of the bag, shaved, and cleaned with ether.

Without soaking the seal the bag is washed with strong Dakin's or Milton 20%, and the orifices are opened up from inside the bag with blunt pointed scissors. The arm is then slipped into the bag — with the thumb opposite the lower inlet — thus obtaining full benefit from the extra width.

The seal is closed down on the previously prepared area of the forearm, any excess is folded over, and it is then reinforced with the special strapping provided.

The bag is then irrigated with diluted Dakin's solution at a temperature of 100°F. To perform this irrigation I employ a typical 5 gal. copper with tap from the G.1098 stores, a length of rubber tubing and a selection from a number of sterilised glass rods 8"-10" long. The seal must be protected during the irrigation by tying round the arm just distal to it a length of bandage or, if still obtainable, a length of elastic band. The irrigating fluid is directed as a stream on to the burnt area with the glass rod, and a large volume of fluid is run over the area — i.e., a number of pints. At no time is the fluid allowed to collect and distend the bag. If pain results from the irrigation the temperature of the solution is probably at fault. If not, then the strength of the solution should be reduced to a half.

After the irrigation the bag is dried by running through oxygen—again being careful not to distend, and deflating carefully after treatment. The entry and exit holes are then sealed off. The life of these bags is approximately 14 to 21 days, and in fact this gives plenty of time to get the areas ready for grafting.

I have found that irrigations only need be done twice a day—morning and evening. If there is much discharge, then the number must be increased to 3 or even 4 times a day, but this is not often necessary.

After drying the bag sulphanilamide or penicillin powder can be blown over the areas as required before sealing down.

It is necessary to combine this treatment with organised exercises, either during irrigation or in the ward between irrigations. Elbow and shoulder movements must not be forgotten. It is still all too easy to nullify much of its value if full advantage is not taken of the bag's transparency actually to supervise and continually to assess the fullest possible movement of all joints.

### Splinting

External splinting can be applied when so desired. Accurate splinting of the thumb and fingers I have found to be impossible. It is impossible also to separate the fingers in a severe burn.

I would summarise the advantages of this method of treatment as follows:—

- (1) The treatment can be applied from the word "go," and maintained up to the time of healing or of grafting.
- (2) No dressings are necessary. If the irrigations are conscientiously carried out and the seal does not leak, cross infection is practically impossible. The only access to the bag is via the sterile glass rod.
- (3) The increased comfort of the patient in the absence of all restricting dressings.
- (4) The absence of flies.
- (5) Physiotherapy is possible throughout, without disturbing the dressings. The optimum time for grafting is easy to assess.
- (6) The ease with which sloughs separate to leave a clean granulating area.
- (7) The minimum of specialist knowledge required to perform clearly a whole series of irrigations. The firm's batman could do the job easily with very little instruction.

The disadvantages of the method are, firstly, that it is time consuming, and secondly, that the accurate separation and splinting of the fingers is not possible.

### After Treatment

As soon as the hand has healed or the sloughs have all separated, then the bag should be removed.

In the first case protective dressings may become necessary for small unhealed areas that may be found. The healed areas require continued physiotherapy until full function and normal skin protection are achieved. In the second case I only now remove the envelope in the operating theatre at the time of grafting.

A sheet of intermediate thickness Thiersh graft is cut from the thigh, spread on to Tulle Gras and applied as large sections to the granulating



areas. For example, with loss of skin over dorsum of hand and all fingers, I employ a separate sheet for each finger, one across the knuckles, and another proximally.

I do not curette or prepare the granulations in any way other than by wiping them down carefully with saline and powdering with penicillin powder. In connection with penicillin in Thiersh grafting, I have over a number of months tried three techniques:—

- (a) A series of dressings at 2 - 3 day intervals, and then graft over the powder.
- (b) A blitz technique—2 - 3 days running—dressing with powder, then grafting over the powder.
- (c) Cases in Bunyan Stannard envelopes—powdering once only, at the time of the graft.

My percentages of graft takes were roughly the same with each method. Over the Tulle Gras I employ narrow ribbon gauze which I stick with mastisol to the normal hand skin exposed. The hand is then put up with a large ball of flavine and paraffin wool in the palm, and with flavine and paraffin wool packed in between and across the fingers over the grafts. A firm pressure dressing over all this with the wrist cocked up in a small plaster slab, and the operation is completed.

The dressing is taken down after four days and replaced with pressure to the end of the week when movements are started again and the hand redressed every day or two until it is healed.

### Discussion

*General Monro.*—As regards the reference made to the Stannard envelope, I think I am correct in saying this has been authorised as part of the standard first-aid equipment of all armoured formations.

*Major C. D. P. Jones.*—The question of burns has interested me vastly during the past four years. During the battle of the Gothic line I was presented by a Padre with a bag which he thought would make a good tobacco pouch. These bags carry cordite charges for the 155 mm gun, the American Long Tom. It struck me at the time that it would make a good covering for burns. My personal practice has been that when a patient comes in with burns I take him to the theatre and wash the burned limb carefully and gently with saline under intravenous morphia. I then gently smear the limb with liquid paraffin and put it in the bag. The bags can easily be sterilised, and are easily obtainable by forward surgeons. They can be sealed, and altered in shape by a flat iron. My theatre orderlies have put on thumb pieces which work very well indeed. I had one officer patient with extensive burns of the arm. He poured out 25 ounces of serum per day for seven days. As regards exercises in these bags—I found I could get patients to move their fingers and thumbs very quickly. These exercises should not be left to the sister or the orderly but should be the responsibility of the surgeon. In the first five days of this battle four surgeons were working with me. We covered 250 priority one cases. The wards were working at tremendous pressure, consequently the orderlies could not find time to supervise men working their hands. One thing about exercises, there is a tendency to ask patients to move their fingers as though they were playing a piano. I think it essential that all four fingers should be moved together and the thumb brought up into opposition.

*Lt-Col. Latchmore.*—There is one point I would like to bring before the meeting. In some of the worst burns of the hands and feet seen in war-time I believe there is occasionally a place for the use of the decompressive incision. This seems an extreme view, but I will describe a case in which it had a place. An Italian child was brought in suffering from very severe burns of the feet caused by a mine. While cleaning the first foot I noticed that it was so tensely swollen with œdema that all the toes were stiff and dead white. (You will remember that when a hand loses most of its epidermis in a severe burn, the common appearance is to find the exposed dermis scarlet on the palmar surface, where the skin is thick and adherent, but often white on the dorsum, where the thin skin is stretched tight by œdema. The change from scarlet to white is striking along the sides of the fingers. Now when the heat trauma has been greater, the tension in the hand or foot can rise to such an extent that the blood is pressed even out of the thick palmar skin. The dermis may also have been coagulated and made less elastic by the heat. In such a hand or foot, dead white with tense œdema, I feel that the circulation is jeopardized and that there may be some place for decompressive incision.) I know this sounds an extremely unusual procedure. In this Italian child, as I cleaned the first foot, I said to my anaesthetist "I am sure a decompressive incision down the front of the ankle could help this foot." I didn't do it, but when I came to the other foot I was astonished and delighted to find that the pressure in it had been so great that the skin had burst spontaneously in a split right down the dorsum, and serum was pouring out from the exposed white subcutaneous tissue glassy with œdema. I then incised the first foot. I have never applied this to a hand, but I feel that cases may occur in which such incision would help.

*Wing Commander Nash, R.A.F.*—It is most impressive to see what is going on, for we in the R.A.F. lead a cottage hospital sort of existence at the base.

There is one thing I would have liked to have said on Monday and which I think may be mentioned here, which characterises Air Force wounds, and that is that our men go into battle clean, and if they get injured they come back clean, if they come back. Therefore the number of wounds which can be regarded as clean is very much greater than amongst soldiers.

With regard to burns of the hand. One speaker has already stressed the point of fluid loss. I use these Stannard envelopes for the first three or four days in burns of the hands. Patients hands are more comfortable in these bags. It is quite common to see half a pint of plasma in each bag during 24 hours, and it is amazing how clean the plasma seems to stay if it is left alone.

I was interested to hear Major Battle's comments on anaesthesia. I think the use of general anaesthesia is to be greatly deprecated. We are in a fortunate position in having baths for the initial treatment of a man who may crash at the base; he may be admitted within an hour of his injuries and as many of such cases as possible, are put into the bath, dressed and treated.

Many Air Force burns are associated with severe fractures of the spine for instance, which give further trouble in treatment and anaesthesia.



One other point I would like to add about grafting. That is, it pays to cover up the knuckles at the earliest moment with patch grafts. This should be done even in the presence of extensive sloughs.

*Lt-Col. R. A. King.*—In our experience of burns in the Army, we have had a very high percentage due to accidents, and it seems right that the common soldier should be educated more thoroughly in the physical properties of these volatile oils such as petrol and paraffin.

I was interested in Major Battle's paper and would like to endorse his remarks regarding dressings. There seems to be a fashion among some medical officers and sisters to favour a dressing of saline on lint or gauze, and of course this dries in a short time, and when the dressing is changed there is a good deal of trauma to the surface. I do think it is very important that non-traumatic dressing should be used such as vaseline gauze or sterile No. 7 paraffin.

I once had the dismal opportunity of dealing with seven cases of burns in which the men were burned over about 90% of the body area. One of these men lived for nine days, and during that time he had a total of just short of 40 pints of plasma. The weather at this time was very hot, between 95 and 100° in the shade in Algiers. Having such extensive surfaces involved, one or two were dressed, unfortunately, with vaseline packs until I realised they were getting heat stroke. The whole lot died. I am sure that two of these men suffered directly from heat stroke.

*Major MacPherson.*—Major Battle has stressed that the value of the early dressing lies in protection, and I am most impressed by the long sleeves which Major Jones has produced today. I have been using a small sulphonamide mitt for some time in burns of the hand for the early dressing, and the ease of its application and the way in which full use of exercises can be practised in it seemed to me to be a great virtue.

I have found that CTAB was by far the most valuable cleansing agent I have come across.

Another idea which I have borrowed through Capt. MacDonald from the Canadians was the use of double strength plasma in reducing oedema, particularly in burns of the hands and of the face, because these are areas in which you can literally see oedema disappear before your eyes after its use. It is a very soupy solution and has to be put in under considerable pressure. Although needing attention whilst going in, the results are quite amazing.

The third thing which has impressed me is the importance of choosing the best time for evacuation in burns. The man's mental condition gives you an extraordinarily good idea when to send him. As Major Battle has said, during the first short period of resuscitation he becomes mentally clearer, but there comes a period when he becomes mentally duller. He is unable or unwilling to do things for himself. As he recovers from that, the time for evacuation to a base unit draws nearer, and when he is mentally orientated and able to ask for what he wants, then, provided other conditions are equal, I think the time for sending him back to the base has arrived.

*General Monro.*—On behalf of all you I should like to say how much we appreciate Wing Commander Nash's remarks and how pleased we are to see the R.A.F. at this meeting.

It looks as if this discussion is splitting on the question of whether to immobilise or whether to get the fingers to move early. Here I think the views of our American colleagues would be most welcome, and I would like to hear what Col. Churchill has to say. Before we ask him, I think there is one point mentioned by Col. King. The question of heat hyper-pyrexia in extensive burns will always arise. This is a problem we are going to have to face in Burma. We will have to guard against it.

*Colonel Churchill.*—I am sorry you have asked me this difficult question! I think in general in the local treatment of burns we use the simplest possible application which with us usually means vaseline gauze, or even dry gauze, and then apply a pressure dressing and leave it alone. To apply a pressure dressing on the hand, gauze is inserted between the fingers and the hand immobilized in position of function. Obviously we do not expect to attain early motion.

I think our surgeons are fairly well agreed that in the first 10/12 days, the hand should be immobilised in the position of function, with firm pressure to control oedema. Any difference of opinion as to the desirability of motion will come after that point. There are certain proponents of still longer immobilisation until complete healing is accomplished by grafting. When there are unhealed areas it is believed that motion simply pumps more lymph into the tissues and causes more fibrosis. Others believe that motion should be started after the acute reaction has subsided without waiting for complete healing.

One other point of difference. There is a definite trend towards very minimal disturbance of the burns in the primary treatment. We have discontinued our efforts to completely cleanse a burn and simply wrap it up and rely on parenterally administered chemotherapy. I think in general our surgeons have been very glad to accept such a very simple method of management.

*Major-General Mitchiner.*—I do not think I have anything interesting to say on this problem. The older I grow, the less I know about burns, and the more I am interested to see we are reverting to methods which were introduced when I was a dresser 40 years ago, which we have given up and taken to again. I do not think the results are any better for this local treatment. I agree with Col. Churchill that the less we interfere with burns the better. Personally, I was very much impressed by the German surgeons who, 15 years ago, were using early pressure treatment — a very efficient pressure treatment with starch and bismuth bandages. Their results were extremely good. I must say I have not seen much of the pressure treatment, but what I have seen, has impressed me very favourably indeed. Every branch of the fighting services has its own problems, and as Wing Commander Nash has said these vary very much from the Royal Air Force in the Army and the Navy. I still think, in spite of being prohibited from saying so, we shall get tannic acid back!

*Major Battle.*—The crux of the situation, gentlemen, is that we appear to be divided into two schools. We do, however, agree that the severe burn must be immobilised. I do not think there is any place for Col. Latchmore's incision, but I was most



interested to hear of the double-strength plasma injection for the control of edema. It would be a great relief to me if we could avoid early movement in burns of the hand. That would appreciably cut down the amount of work we have found necessary in the active treatment of these cases.

When so distinguished a person as Col. Churchill stands up on behalf of the American services and tells us that pressure and immobilisation are necessary, we must take this very seriously, and I, for one, will certainly change my technique and see if I can better results from this method.

## OBSERVATIONS ON ALTERED PROTEIN METABOLISM AFTER THERMAL INJURY

by

Captain SOMERS H. STURGIS, M.C., A.U.S.

### Introduction

A severe burn must be cared for with foresight and planning, and with a knowledge of the clinical crises that may arise from the unique features of thermal trauma. Physicians have found it pertinent to recognize different stages in the progression of a case from injury to convalescence, for each one presents its own problems in therapy. These stages will be defined as follows for the purposes of the present discussion:—

- I. From 0 to 24 hours—the phase of shock.
- II. From 2 to 10 days—the phase of delayed visceral damage.
- III. From the fourth day on—the phase of sepsis.
- IV. From the tenth day on—the phase of malnutrition.

The particular reaction to injury from a burn that demands especial handling of these phases results from an altered metabolism induced by plasma loss. For it is not alone the decrease in blood volume, nor the haemoconcentration, nor the edema per se, but the loss of circulating plasma proteins that is fundamentally important, and that involves a fundamental threat to vital processes. It is, therefore, essential to the clinician to examine the effects of changes in protein metabolism—the compensating mechanisms, and the supportive measures now available—in order to anticipate the lethal factors associated with each of the stages outlined above.

*I. The Phase of Shock.* The trauma of external heat rapidly renders exposed capillaries semi-permeable to the molecules of the serum proteins, and the fluid escaping into the extracellular tissue spaces soon approximates the colloid composition and osmotic pressure of the blood stream. Rossiter (1) has pointed out that the blood is thus deprived of the principle mechanism—osmosis—whereby it can replenish its water content. It has been experimentally shown that if protein is washed from the circulation by plasmaphoresis, this deprivation alone can precipitate shock. An immediate mobilization of protein reserves into the blood stream is therefore urgently necessary to compensate for the continuing loss of plasma through injured capillary walls. Recent investigations (5) have demonstrated the normal “dynamic state” of body protein. Thus certain amino-acids have been “tagged” with heavy isotopes of carbon, hydrogen or nitrogen, and when these “tags” are traced it is seen that more than half the liver protein may apparently be

broken down and re-synthesized within 10 days. Indeed, it is probable that most tissue proteins are constantly undergoing degradation and re-synthesis with a continual opening and closing of the peptid links. This concept makes it easier to understand the rapid deployment of tissue protein to compensate for a falling plasma protein level. The breakdown of tissue deposits and their re-synthesis into albumen, globulin and fibronogen takes place chiefly in the liver. The formation of these polypeptides involves selection rather than total utilization of the galaxy of amino-acids resulting from the breakdown of protein stores. The unused amino-acid aggregates contribute fuel for energy, and waste nitrogen—split off as ammonia for conversion into urea—becomes one of the excretion products of their de-aminization. Fractionation of the non-protein nitrogen in blood and urine after a burn may show not only the high urea content that might be expected but also, and of more importance, a marked increase in so-called “residual nitrogen”. The source of this undetermined nitrogen is not clear. Drinker and his co-workers showed that lymph collected from a burned extremity contained no greater per cent of non-protein nitrogen than the lymph collected from the other, control limb. He concluded that tissue destruction at the site of injury did not contribute significantly to the increase in nitrogenous degradation products in the general circulation. It is, therefore, likely that a rise in NPN and urea formation results primarily from the utilization of systemic protein reserves. The function of the kidneys must be maintained, for otherwise nitrogenous waste accumulates in the blood and an irreversible azotemia may result. Kidney function may be threatened not only by the after-effects of severe shock, but also, by the presence of hemoglobinemia. Lysis of red cells may occur in burns as a result of destruction of blood in tissues directly exposed to heat. Hemoglobin or its derivatives are precipitated in the presence of an acid urine to form deposits in the kidneys. It is important to alkalinize the urine, therefore, if this complication is suspected to prevent such deposition. The use of sodium bicarbonate for this purpose may have an added beneficial effect, for Fox has recently called attention to experiments that first suggested the importance of sodium metabolism in a burn. It was demonstrated that a normal diet deficient only in sodium may be associated with the development of a negative nitrogen balance.



Although depletion of deposit protein is rapid, its reaccumulation is slow. The replenishment of these depleted sources of endogenous protein depends on exogenous supplies—that ingested and that given intravenously. The former, absorbed into the blood stream as simple amino-acids, again adds its quota of waste nitrogen to the products of tissue catabolism in the circulation. Present purification methods make available concentrated solutions of albumen, globulin and amino-acid mixtures for administration by vein. None of these preparations, however, has been shown to contain any specific advantage over plasma while capillary permeability persists, and plasma is still considered to be the treatment of choice for burn shock. The liver is the key organ in these metabolic processes, and excess nitrogen is the chief waste product in the body's effort to replenish an acute loss of protein from the vascular bed.

*II. The Phase of Delayed Visceral Damage.* Fatalities occurring from two to ten days after a severe burn may exhibit a confusing variety of symptoms, including acidosis, azotemia, hyperthermia, oliguria and albuminuria and hemoglobinuria. Yet, bearing in mind the essential part played by the liver in protein metabolism, damage to this organ may often play a major role in the metabolic failure to survive leading to a so-called "toxemic" death. Autopsy material from cases treated with tannic acid has consistently shown a high incidence of central necrosis in the liver. For this reason, Lt.-Colonel W. C. Wilson, in his excellent report on burns in the Middle East Forces (6), advises against the use of tanning solutions. Since the abandonment of escharotics, however, fatalities from "toxemia" still occur, and liver dysfunction among severe burns is still reported by McClure (7) to be found in 9% of cases. Collateral evidence of liver damage after a burn injury is seen in the experiments of Shorr (8). Studies of liver sections in vitro removed during burn shock showed that oxygen consumption and urea formation were apparently normal. This was contrasted with a diminished oxidation and urea formation after bleeding shock in similar liver slices. The possible explanation for this difference between bleeding and burn shock may be that both cases suffered liver damage. Such damage, however, was manifested after bleeding by lowered oxidation, whereas, after burning it was masked by the increased metabolic rate and oxygen consumption of the unimpaired liver cells. The need for increased protein metabolism by the uninjured elements in the burn case thus was recorded, not as a decrease in oxygen consumption, but as a relatively normal rate. The significance of anæsthesia, drugs, infection or anoxemia resulting from severe shock in altered metabolic exchange and visceral damage is not yet clearly understood.

*III. The Phase of Sepsis.* In spite of sulfonamides and penicillin, sepsis is still reported in 30 to 40% of severe burns. Infection itself increases tissue destruction and is attended by a rise in temperature. Both these factors imply an increased rate of protein catabolism. The only way to prevent the burning of protein for energy to meet increased metabolic requirements is to make available sufficient carbohydrate and fat over and above the normal caloric requirements. Infection is frequently associated with the onset of anæmia by the 6th to the 10th day. Whole blood transfusions are doubly important during this stage since they provide not

only red cells, but also the globulin fraction of plasma that, according to Cannon (9), contains the antibody mechanism for combating infections.

*IV. The Phase of Malnutrition.* The "waste" nitrogen that results from increased protein metabolism is converted in good part into urea, and excreted by the kidneys. The accumulating negative nitrogen balance recorded in severe cases may reach astounding figures (10). This deficit must be restored by means of a high protein intake, since protein synthesis does not occur in the body. Every effort should be made to have the patient take by mouth at least 100 gms of protein daily. Severe burns, however, may show an excessive degree of protein depletion, and in such cases amigen, the protein (hydrolysate), as well as concentrated albumen given by vein, has been used successfully. Amigen, however, is not a "complete" protein; nitrogen equilibrium cannot be maintained by this compound alone, and the sulphur-containing essential amino-acids must be given as well. Great care must be exercised in its preparation for intravenous administration to avoid severe untoward reactions. Its use by vein should probably be limited to those desperate cases in which it may carry a patient temporarily past a period of inability to take food or fluid by mouth. Under these conditions it may prove to be a valuable supplement to concentrated albumen, or plasma and whole blood.

However, it is only when the burned area is finally covered again with epithelium that the metabolic crises induced by the sequence of massive plasma loss, major depletion of protein reserves and inadequate protein intake are relatively easily overcome.

In conclusion, it may not be out of place—in view of the increasing use of flame-throwers on both fronts of the global war—to add a few remarks on the results of exposure to this weapon, and the new problems in therapy thus presented to the Medical Corps.

Investigation into the lethal effects of flame-throwers reveals a number of factors other than those resulting from a direct burn that may contribute to the death. Flame is used most effectively against strong points where the enemy is well protected from other weapons, but is confined in a narrow space. The immediate result obtained by flame against such emplacements is (1) a sharp fall of oxygen to zero in 60 seconds, (2) a precipitant rise in carbon monoxide in the same time, (3) a rapid concentration of non-combustible gases, and (4) an immediate increase in temperature to the neighbourhood of 250° centigrade. The victim of this attack may die from anoxemia, from carbon monoxide or poisonous gases, or from thermal injury. The effect of the sudden and tremendous increase in environmental temperature, even when there is no actual surface loss of skin, is not yet clearly delineated. The critical level of fatal exposure may be expressed as the product of the caloric bombardment per square centimeter of surface exposed per minute.

It may be well for the Medical Corps to bear in mind the complicated pathology expected in soldiers who have had a sublethal contact with flame in a confined space. Other metabolic alterations in these cases may prove to be even more vital to survival than those commonly associated with the usual severe burn.



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## THE RELATIONSHIP OF WOUND HEALING AND PROTEIN METABOLISM

by

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Surgeons have shown a marked interest in wound healing since early times. Pare, John Hunter and Lister were especially concerned with the problem of wound repair. Since, as surgeons, we often make wounds, it is fitting that we should always strive to secure the best possible repair of the body tissues. The problem of wound healing is a very broad one, being affected by many local as well as general factors. The present discussion is concerned primarily with the relationship of protein metabolism to wound healing; nevertheless, it would be a mistake not to mention some of the other factors concerned, since the various factors in wound healing are closely related.

## GENERAL FACTORS INFLUENCING WOUND REPAIR INCLUDE:

(1) Age of the patient; (2) temperature variations; (3) Water balance; (4) nervous influences; (5) the presence or absence of certain debilitating diseases; (6) diet, with reference to food and vitamin intake; and (7) the protein and vitamin reserves of the body. (1), (2), (3), (4).

Among important local factors affecting wound healing may be mentioned: (1) Trauma; (2) the presence of necrotic tissue or other foreign material in the wound; (3) local blood supply; (4) the presence or absence of dead space within the wound; (5) hematoma; (6) pressure abnormalities, whether too much or too little pressure is applied; and (7) infection. (3), (5).

## METABOLISM OF PROTEIN

A brief review of certain known features regarding the body metabolism of protein will prove of value before presenting the evidence concerning wound defects related to deficiencies in protein.

Foods containing a majority of the essential amino-acids are referred to as high quality proteins. The body utilizes such high quality materials to fabricate the proteins of the plasma and the tissues. (6), (7). The plasma albumin and fibrinogen seem to be formed in the liver. Plasma globulin is formed in the liver, but also to some extent in other organs making up the reticulo-endothelial system, namely in the spleen, bone marrow and lymph nodes. Like-

wise, hemoglobin is formed by the reticulo-endothelial system. The liver is concerned with the storage of protein as well as with its formation.

Deficiencies in the plasma and tissue proteins may be restored from endogenous or exogenous sources. In the latter case, such restoration is by dietary intake of adequate proteins or by the intravenous injection of blood, plasma or hydrolysates of amino-acids.

The endogenous replacement of plasma protein loss is from the protein stores of the tissues. A state of dynamic equilibrium is thought to exist between the tissue and plasma-protein. In case of an acute loss of plasma protein, however, as occurs following a severe hemorrhage or an extensive burn, only a part of the tissue protein is available for immediate replacement.

Methods are available for the determination of the plasma protein level of the individual, the normal being usually given as 6.5 to 7 grams per 100 cc, with a ratio of albumin to globulin of 1.6 to 1. A single determination of plasma proteins in a given case may fail to give a fair picture of the state of protein reserves. (8). This is true because (1) dehydration may mask a deficiency; (2) the albumin fraction, so important in water balance, may be greatly decreased with a concomitant rise in globulin due to infection or liver disease; and (3) the tissue protein reserves may be greatly depleted before this is reflected by a change in the plasma determination. Unfortunately, no satisfactory method is available for determining the state of the protein reserves. (9). In the absence of such methods, the clinician must depend upon such evidence as weight loss, the amount of tissue exudates from burned or traumatized surfaces, the history of protein loss by bowel fistula, gastric suction, or from disease of the liver or kidney. Thus the length of time before an inadequate protein intake or a continued deficit of protein becomes a serious problem is directly related to the amount of tissue protein present at the time the inadequate intake or excessive loss began. From the above it may be seen that it is more accurate to speak of protein deficiency rather than of hypoproteinemia.



## SOME RESULTS OF PROTEIN DEFICIENCY

Many changes occur in the organism as a result of protein deficiency. Some of these changes are: (1) An alteration of water balance with resultant tissue edema. This tissue edema produced by hypoproteinemia is responsible for several sequelæ, all of which are unfavourable to the surgical patient. These include an increased likelihood of infection and a delay in emptying time of the stomach and small bowel. (2). Changes in the fibroblastic reaction of the wound result from hypoproteinemia. The fibroblasts in the wound of the protein deficient animal are fewer in number and later in appearance than in the normal animal. (3) Globulin deficiency, occurring with the general protein loss, results in a smaller amount of immune substances, since antibodies consist of gamma globulin, a specialized form of protein.

## EFFECT OF PROTEIN DEFICIENCY IN WOUND REPAIR

Carrel called attention to the fact that protein served as a stimulus to successful wound healing, and later Clark's experiments substantiated this finding. (10), (11). Harvey and Howes reported an increase in fibroplasia and consequently more rapid healing in experimental animals receiving a high protein diet as compared with those kept on a diet deficient for a long period of time. (12). Ravdin, Thompson and their associates have recently done much to acquaint surgeons with the general importance of the problem. (13). These investigators showed very definite abnormalities in wound repair in dogs rendered deficient of protein by plasmaphereses. Wounds in dogs with severe hypoproteinemia were shown to be edematous and to contain an increased amount of fluid grossly. The tissues appeared pale and did not seem to bleed normally. Microscopically, there was an increase in extra-cellular fluid and the tissues appeared edematous. Sections of seven-day wounds showed few fibroblasts to be present. Sections of wounds 14 days old revealed fibroblasts to be present, but the fibroblastic reaction was much less than that seen in the wounds of normal animals. These wounds showed a great decrease in tensile strength, and many of the animals suffered from wound disruptions. It was also reported that catgut lost its tensile strength sooner in hypoproteinemic animals than in normal animals.

Wounds in hypoproteinemic animals could be caused to heal normally provided a sufficient amount of plasma was given post-operatively. In other experiments these investigators demonstrated that protein deficiency, besides retarding normal wound fibroplasia, also caused a delay in the emptying time of the stomach and a decrease in intestinal motility. They also reported a delay in the formation of osteoid and callus in dogs with experimental fractures.

Numerous writers have called attention to the connection between hypoproteinemia and wound disruption. (14) (15). Although it is likely that an important relationship exists in some cases, one must be careful in assigning a single cause for disruption when there are so many variable factors in almost every case of wound dehiscence. Infection notoriously interferes with normal wound repair. It is easy to see why the edematous tissues of a patient with marked hypoproteinemia would be more susceptible to infection.

Cannon has called attention to another method whereby protein deficiency makes infection more

likely to occur namely by disrupting the normal body processes concerned with the natural, and acquired immunity of the individual. (9). It is logical that prolonged undernutrition or excessive protein loss should affect adversely natural immunity, since protracted protein deficiency leads eventually to atrophy of the liver, spleen, bone marrow and lymphoid tissues, and it is from these tissues that most of the phagocytic cells originate. Of equal or greater importance in combating infection caused by common pathogenic organisms is acquired resistance. Antibodies have been shown to consist of gamma globulin, a specialized type of protein. When the body is markedly deficient in protein it will be unable to exhibit the normal antibody response to infection because of the lack of protein from which gamma globulin may be fabricated. Thus in some hypoproteinemic animals it has been shown that the gamma globulin may be reduced to from 20 to 30% of normal.

## EXPERIENCES WITH PROTEIN REPLACEMENT THERAPY IN SURGICAL PATIENTS:

In military practice, I have had the occasion to observe more patients with an acute protein loss than with a chronic or gradually developing protein deficiency. Almost all of the patients I have observed with an acute hypoproteinemia have suffered from very severe burns, or from severe accidental hemorrhage. The fewer cases of hypoproteinemia of chronic origin personally observed in soldiers have been in battle casualties who have had severe injuries involving the abdominal viscera or the thorax. In these individuals protein intake was inadequate over a significant period of time and large amounts of protein had been lost in some instances by gastric suction, ileostomy drainage, or from exudation into the thoracic or peritoneal cavities. In civilian practice, the protein deficient state was seen more frequently in elderly patients with diseases of the gastro-intestinal tract, notably in obstructing duodenal ulcer and in malignancies of the stomach and bowel. In addition some of these patients had liver disease which interfered with normal protein metabolism.

In our military experience, dealing chiefly with young adults who were previously in good general condition, we have almost always been able to correct protein deficiencies when found. I do not feel that this has been an important factor in delayed wound healing in the patients we have treated.

Replacement therapy is best carried out by giving the patient an abundant amount of high quality proteins by mouth when such is possible. When oral feeding is impossible, or when it requires supplemental methods, we have chosen to give large amounts of plasma and whole blood. Since one unit of plasma contains only 18 grams of protein the amounts of plasma or blood required for replacement therapy may be very large. However, we believe at present that this is the safest way to tide the patient over until an adequate dietary intake can be established. Recently, preparations of amino acids suitable for intravenous use have been introduced for replacement therapy. Amigen, a hydrolysate of casein, prepared as a 5% solution in 5% glucose, has been used at home and in this theatre. A litre of this solution contains 50 grams of protein, and it has been found that it can be given intravenously with relative safety. This appears definitely to be a step in the right direction, however, it seems

likely that a better product will be found for parenteral protein therapy. This casein hydrolysate must be given very slowly if one is to avoid reactions, and also there is a tendency for it to cause thrombosis of the vein into which it is injected. Although my personal experience with this material has been quite limited, Colonel Kirtley, of our 300th General Hospital, recently told me that he had given approximately 124 litres of amigen. He was not at all enthusiastic because he felt that one out of three of the patients receiving the digest had suffered a severe febrile reaction from it and because many had received thrombosed veins.

Perhaps many of these reactions could have been avoided by utilizing four hours for each litre injected. This, in itself, however, is an undesirable feature of the method.

#### SUMMARY AND CONCLUSION:

1. Some of the important factors regarding protein metabolism have been reviewed and the importance of adequate protein reserves to the body have been pointed out.

2. The difficulty of securing adequate information regarding the state of protein sufficiency from a single plasma determination is stressed.

3. Marked protein deficiency is believed to interfere with normal wound healing chiefly because:

- a. Fibroplasia is retarded.
- b. The wound is rendered edematous.
- c. Infection is more likely to occur as a result of a decrease in gamma globulin of which antibodies are composed.

4. Replacement therapy consists, in the order of importance, of a high protein dietary intake, blood and plasma transfusions, and hydrolysates of amino acids suitable for intravenous use.

5. In the cases of protein deficiency personally seen in this theatre, the above methods of replacement were adequate, and we have not observed delayed wound healing in soldiers due to hypoproteinemia.

6. It is agreed that the general factors of diet, hydration, and maintenance of normal blood and plasma levels are important. It is equally important that we never lose sight of the necessity for good surgical technique, including rigid hemostasis, the removal of necrotic tissue, the maintenance of an adequate blood supply, the avoidance of dead space in the wound, and the proper closure of the wound at the optimum time.

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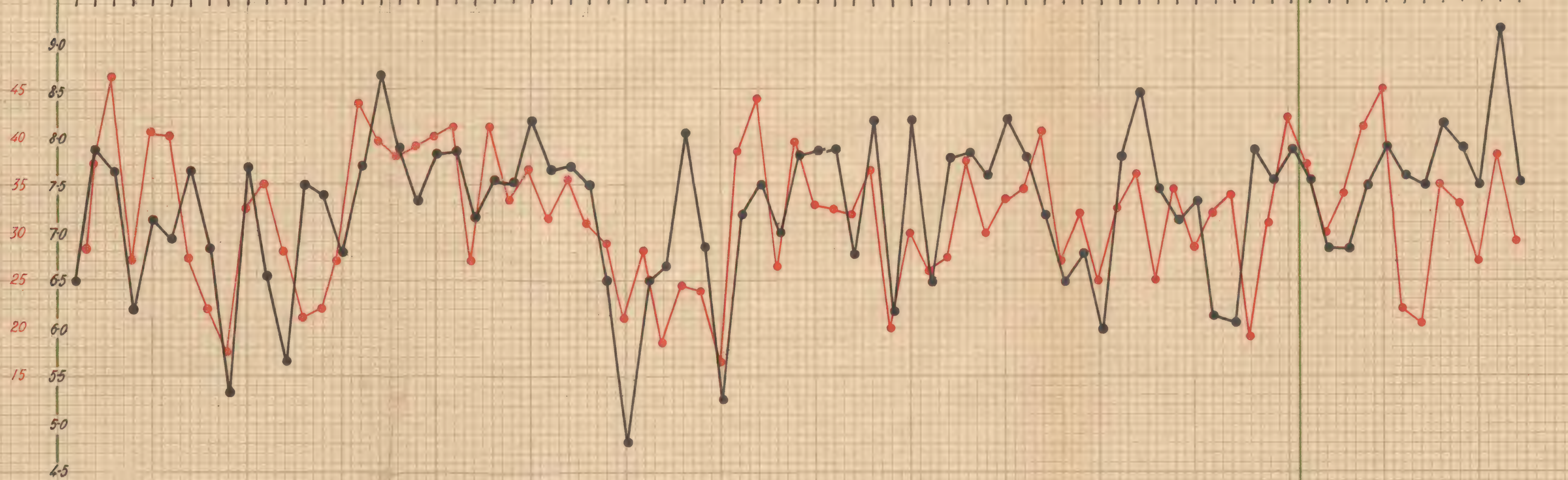
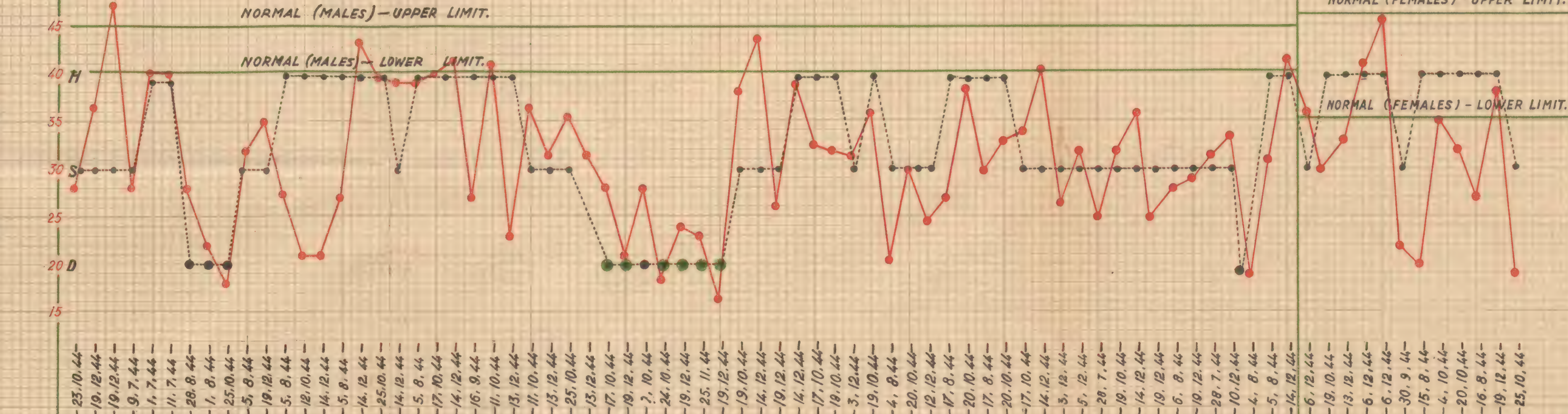
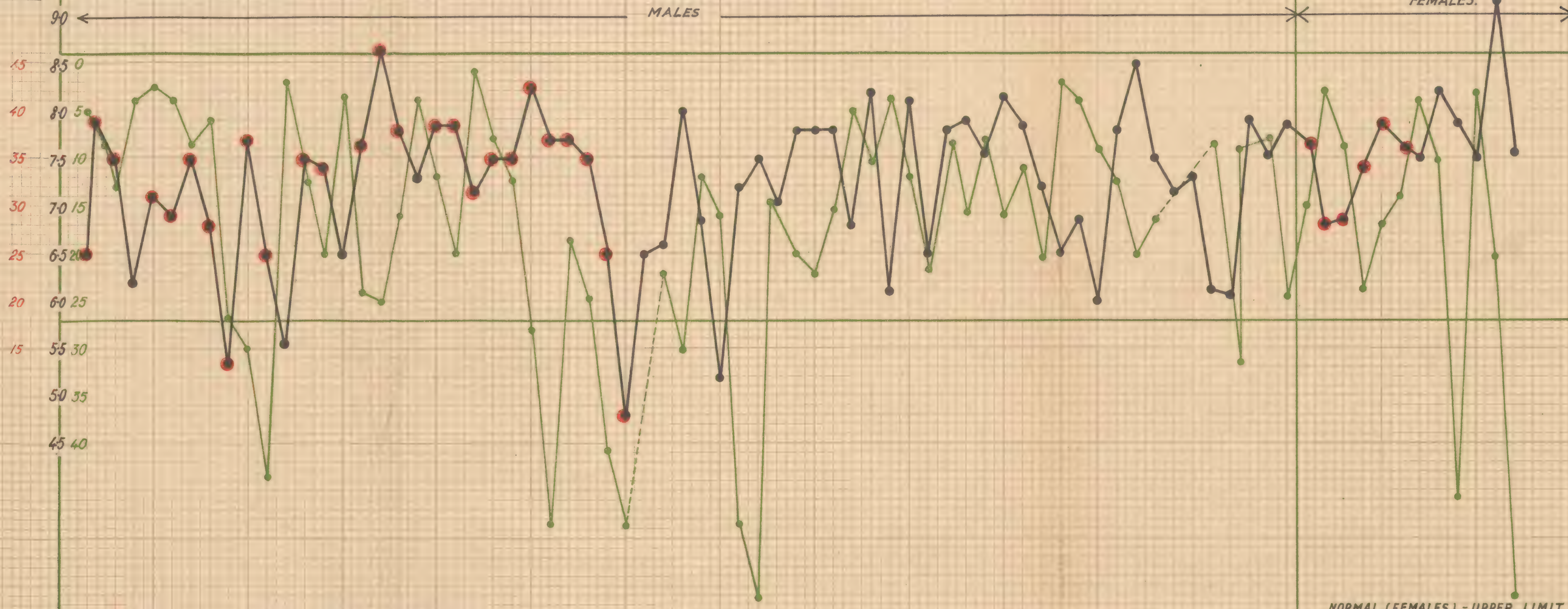
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*General Monro.*—To those of us whose academic ration did not include this somewhat modern biochemical background, I am sure a lot of this, speaking for myself, is a little above our heads. However, I congratulate Col. Harwell Wilson for the remarkable way in which he has dealt with this complicated subject, and the sound practical conclusions he came to, and we are very grateful to see him and his American colleagues at this meeting.



PATIENT'S INDEX No.:

1 1 2 3 4 5 6 7 8 9 9 10 11 12 13 13 14 14 15 15 16 17 17 18 19 19 20 21 21 22 23 24 25 26 27 28 28 29 30 30 31 32 33 34 35 36 37 37 38 39 40 41 41 42 43 43 44 45 46 47 47 48 49 50





## PLASMA PROTEIN LEVELS IN CHRONIC SEPSIS

by

Major R. S. GARDEN, RAMC

What I have to describe are the preliminary findings of an investigation which has been carried out to determine the value of plasma protein estimation as a guide to treatment in chronic sepsis. A total of 77 blood examinations have been made in 50 patients suffering from well-established infection. The majority of these patients were Yugoslav battle casualties, and there has been little doubt as to the chronicity of their lesions. Many of these remarkable people had had no resuscitation or primary surgery, and came for treatment months, and sometimes years, from the date of wounding. Their condition on arrival was in striking contrast to that of British wounded. They were often toxic, emaciated and markedly anæmic, whilst abscess formation was frequently enormous.

Of the 50 patients chosen for the investigation, 20 are now healed and have been discharged from hospital, 22 are not yet healed, whilst 5 have died and 3 are likely to die in the near future.

It has been shown, both clinically and experimentally, that copious pus formation is a source of considerable protein loss, and it is not unreasonable to presume that this loss should be reflected in the level of the blood plasma protein. In the present series this has seldom been the case. This finding, however, may be offset by the fact that no significant deprivation of protein in the diet of these patients has been noted either before or after their admission to hospital. Even the seriously ill Yugoslav can still consume large quantities of both protein and carbohydrate as compared with British patients. Lt.-Col. J. Halliday-Croom, R.A.M.C., has made careful enquiry into the diet and physical condition of the patients under investigation and has been unable to find any outstanding evidence either of protein deprivation or general dietary insufficiency.

The results of the investigation have been charted on the accompanying graph, on which the following data have been recorded:—

- Plasma protein,
- Hæmatocrit,
- Number of weeks since wounding,
- Clinical progress, and
- Blood transfusion given prior to examination.

The plasma protein and "number of weeks since wounding" charts have been superimposed, as also have the hæmatocrit and "clinical progress" and plasma protein and hæmatocrit and "clinical progress" and plasma protein and hæmatocrit charts.

Reference to this graph shows that the plasma protein estimations have fluctuated *within* the normal limits of 5.8—8.6 grms per 100cc in all but 4 cases, which have been below these limits.

Again, the "mean normal" range of 6.0—7.3 grms per 100cc has been found to include only 28 of the estimations, whilst 48 have been above and 4 have been below this range. A control series of 50 blood donors have been examined — the same copper sulphate specific gravity method of laboratory examination being used throughout — and, in these,

the plasma protein has varied but little above the 7.5 grms per 100 cc. level. Further investigation may show, therefore, that the accepted range of normality is an unduly wide one, and the plasma protein findings may require interpretation accordingly.

In contradistinction to the plasma protein, the hæmatocrit has been found to fluctuate almost always *below* normal levels. The superimposed hæmatocrit and clinical progress charts have followed each other closely, as also have the superimposed plasma protein and hæmatocrit charts. This may reasonably be taken to show that the plasma protein and the hæmatocrit have been affected by chronic sepsis in the same way.

It seems probable that the blood retains its normal plasma protein content for as long as possible in chronic sepsis, and equally probable that this is achieved at the expense of other tissues. The slight, though sensitive, deviations which have been noted in the plasma protein estimations, therefore, may be reflections of much greater disturbances in the protein content of the tissues as a whole. These estimations may thus be a more reliable guide to treatment than would at first appear. There is ample clinical evidence as to the value of repeated blood or plasma transfusion as an adjunct to treatment in chronic sepsis, and if such therapy is indicated by simple hæmoglobin and orthodox clinical tests the presence of a normal plasma protein should be ignored. The presence of a plasma protein finding of 5.5 grms per 100cc or less, on the other hand, cannot be ignored, and in the present series all patients who have had a plasma protein estimation below the 5.5 grms per 100cc level have died, or are likely to die soon. For this reason, the plasma protein should be carefully watched, and even in the absence of a dramatic variation from the normal its rise and fall appear to be in keeping with the hæmatocrit — and therefore with the hæmoglobin, except in the presence of altered red cell size. It may therefore be assumed that blood transfusion can be given in chronic sepsis with every confidence that, as the hæmoglobin level rises, so will the plasma and general body proteins approach normality.

### General Monro

Major Garden has provided the last link, as his interesting graph on the screen showed. I think it would be fair to say that at the beginning of this war we rather thought chronic sepsis would be a problem. We were inclined to be influenced at that time by closed plaster methods. Speaking of the British services, and I think I can say the same for our Allies, this has not happened, particularly in this Command. This is a matter for great congratulation. We know at A.M.D. the immense drive that has been made in wound closure. This is a most satisfactory thing. When one thinks of the dreadful wounds of the last war, pouring with pus, the labour of going round cot after cot, and the pain which each dressing caused, it is indeed a terrific advance



to think what you have done, particularly in this Command, I believe largely because of the extraordinarily good organisation and set-up, and chronic sepsis is a problem only of the Yugo-Slavs and such people who have not the advantage of this organisa-

tion. I would like to take this opportunity of expressing my gratitude to Brigadier Edwards, Brigadier Stammers, and all of you who have worked in co-operation with them, for this fine effort in getting so many wounds closed at an early stage.

Thursday 15<sup>th</sup> February 1945  
AFTERNOON SESSION

**Subject: VASCULAR INJURIES**

*Presiding:*

Brigadier Stammers, Consulting Surgeon

Brigadier Edwards

As you see, this afternoon is to be devoted to vascular surgery, a subject which still holds many problems. I think you will agree, especially the forward surgeons, that nobody has done more to tackle this problem than my comrade-in-arms, Brigadier Stammers, and I think it very appropriate that he should take the chair at this meeting, and this he has kindly consented to do.

Brigadier Stammers

This is a problem which concerns forward surgeons, and I hope we shall get some information which will help us in this dismal picture. I have asked my forward colleagues to let me know the number of vascular arterial injuries that they have had. They have not all replied, but we have got quite a few. Just to show you the magnitude of the problem, out of 36 popliteal ligations 26 amputations followed, and out of 31 femoral ligations 21 amputations followed. Any information which may come out of this discussion to help us to improve these depressing figures will be valuable. I will now call upon the opener of this discussion, Colonel Mason- Brown.





## A PLEA FOR CONSERVATISM IN THE PRIMARY SURGERY OF WOUNDS OF THE MAIN ARTERIES OF THE LIMBS

by

Lt.-Col. J. J. MASON BROWN, RAMC

In opening the discussion today I am at something of a disadvantage for the experience of war wounds of arteries at the Field Vascular Centre is limited to the results of previous primary ligation and to the complications of arterial injury. In describing what we have done and the conclusions we have drawn from the work of the first nine months I hope that you will have the basis for a free and full discussion today.

The earliest stage at which we see cases other than primary ligations is that of the traumatic arterial hæmatoma. Let us consider the clinical features.

### Traumatic Arterial Hæmatoma

The wound is usually trivial and at some distance from the lesion. Clinical features—Initially these are:—

(1) the presence of a firm tense swelling in or near the anatomical line of an artery.

(2) the swelling does NOT pulsate.

(3) the peripheral pulses are diminished or absent.

The swelling may or may not alter in size but within a day or two the signs change owing to the increased circulation through the hæmatoma:—

(1) the centre of the swelling becomes softer.

(2) pulsation is felt over it.

(3) at first there is a faint blowing systolic murmur, but this becomes louder and rougher as the blood flow increases and a thrill may be felt over it.

(4) the peripheral pulses may be diminished and/or delayed.

In the early stages it is usually impossible to tell clinically whether the vein has also been injured. The initial systolic murmur becomes more and more prolonged until the continuous bruit of the venous lesion becomes established. The greater the venous lesion the less likely are early complications for it acts as a safety valve, and the more rapid is the development of the collateral circulation. In many cases the exact diagnosis can only be established by arteriography or at operation.

As soon as the case is admitted, examination is carried out to assess (a) the degree of peripheral ischæmia, (b) the size of the swelling, (c) pressure on other structures, (d) the state of the wounds, which are usually trivial, healed or healing, (e) sepsis, including the possibility of gas gangrene. If there are signs of pressure on nerves it is important to find out whether the paralysis occurred immediately after wounding or as a later sequela, (probably due then to compression). This examination is important in deciding the need for early operation, the indications for which are (1) hæmorrhage, usually internal and less often external, (2) severe and progressive ischæmia in the presence of a large hæmatoma, (3) pressure on nerves.

Of these the assessment of ischæmia requires further consideration.

### Ischæmia

This disabling complication may arise: (1) at the time of wounding, from complete division of a main vessel with external hæmorrhage, (2) from contusion followed by thrombosis of the main artery, (3) from the development of a traumatic arterial hæmatoma or arterio-venous lesion, (4) from operative treatment, e.g., ligation before a satisfactory collateral circulation has been established.

### What are the clinical features of Ischæmia?

(1) *Loss of the peripheral pulses*. This is not in itself of significance for the collateral circulation may be adequate or the presence of the lesion may cause sufficient lowering of the peripheral blood pressure to make the pulses impalpable.

(2) *Coldness of the limb*. Reliable only if the limb is significantly colder than its fellow under the same environment conditions.

(3) *Pallor of the skin* or if the limb be dependent *cyanosis* from the filling of the dilated capillaries with stagnant blood.

(4) *Loss of muscle activity*, at first of ability to sustain movement, and later loss of power even to initiate it.

(5) *Hypæsthesia or anæsthesia* of the glove or stocking type due to failure of the blood supply to the nerves. In the later stages there may be severe pain.

The diagnosis of ischæmia must never be made on one of these signs alone, and should be based on a full examination of the limb.

### Factors of Importance in the Treatment of the Ischæmic limb

(1) *Environment*. The metabolism of the limb must not be increased by the application of warmth. The limb should be exposed to room temperature. The application of cold is not advisable for it will have the maximum effect on vessels of the skin and may precipitate digital gangrene.

(2) *Position of the limb*. The limb should be kept at least 4 inches below the level of the heart. If the vein be damaged the limb may be slightly elevated on itself to promote the absorption of œdema though still as a whole below heart level.

(3) *Rest*. The limb must be kept absolutely at rest because failure to do this means muscular activity with the diversion of blood to the muscles at the expense of the other tissues. Splinting is best carried out by making a posterior plaster gutter into which the limb is placed, the whole of its anterior surface remaining exposed and no bandages applied.

(4) *Prevention of Infection*. This is of vital importance because infection demands a local increase of blood flow which cannot be spared from the other areas of the limb. Keep the skin carefully dry, pay particular attention to the webs of the toes and use penicillin locally on the slightest suspicion of a blister.



(5) *Reflex vaso-dilatation.* Warmth applied to the trunk and other limbs will result in reflex vaso-dilatation. Cohen has drawn attention to the dangers of this method because it affects only the skin vessels and may therefore endanger the muscles. I have not the evidence for this statement available, but it seems likely that if it relieves the vaso-constrictor tonus of the limb it can only be of benefit by releasing the collateral vessels from spasm and so producing a total increase of the blood flow to the limb. It has been our practice to carry out para-vertebral block and to maintain its effects by reflex vaso-dilatation which is seldom as fully effective as sympathetic block. Para-vertebral block even after considerable experience is a rather chancy method, and in real emergency we have not hesitated to use spinal anaesthesia provided that the patient's condition permitted its employment. On several occasions its effects have lasted long after the anaesthesia has passed off. If a good response is obtained sympathetomy may be considered as a pre-operative measure.

(6) *The relief of tension.* Splitting of the deep fascia in the presence of wounds below the arterial lesion to relieve tension and to prevent infection is sound treatment. As it can obviously have no effect on the tension in or around the arterial hæmatoma it is probably of little value in the absence of these indications.

(7) *General measures.* If the bleeding has been controlled, e.g., by ligation, it is imperative that blood transfusion be given to restore the blood pressure and oxygen carrying capacity of the blood to normal. If the bleeding is not fully under control the risks of causing further hæmorrhage must be balanced against the advantages of transfusion.

Before deciding to operate consider the duration of the ischæmia and its mode of onset. Just as the body can adapt itself to severe blood loss spread over a period, so the limb can adjust itself to moderate ischæmia of a progressive nature, but severe ischæmia of sudden onset in certain to produce permanent disability even if gangrene does not occur. It is safe to treat the moderately ischæmic limb expectantly for a day or two at least, and with the opening up of collateral channels and the return of circulation through the hæmatoma the survival of the limb will be secured.

If operation has to be performed at this stage and ligation is the only possibility should the accompanying vein be ligated also? This vexed question has been the subject of considerable dispute. Is there any evidence that ligation of the vein is beneficial? I must confess that I do not know. It may be that it acts by relaxing the arterial tone, for Lewis and Grant have shown that venous occlusion is followed by re-active hyperæmia. Whatever the mechanism may be the results of vein ligation are certainly not prejudicial and it seems reasonable therefore always to tie both the artery and the vein.

In the absence of indications for early operation how soon is it safe to operate? The answer is easy:—when the best possible collateral circulation has been established and never by rule of thumb. Six weeks has been suggested, and certainly at this time dissection has been found to be easy, whereas in the earlier and later stages in some cases it has been difficult. How can we estimate the collateral circulation? Before operation such methods as histamine wheals, reactive hyperæmia, venous filling time tests and skin temperature can only be a

measure of the total circulation and cannot differentiate between aneurysmal and collateral circulation unless it be possible to occlude the main artery just above the aneurysm by digital compression—frequently impossible and too uncertain. Arteriogram too has its fallacies and it is safer to wait longer if in doubt.

At operation however reliable evidence can be obtained for the proximal artery can be occluded. We have employed the following modification of the Henle-Coenlein test. With a tourniquet the sac is displayed and occlusion clamps applied to the artery immediately above and below the aneurysm. The sac is opened, emptied and any small branch entering it occluded. The tourniquet is removed and after a few minutes the lower arterial clamps is loosened. Any bleeding can only be due to reflux from the collateral circulation which is probably functioning at its maximum due to the reactive hyperæmia resulting from the tourniquet. Little or no reflux from the distal artery is taken as an absolute indication for repair. It is essential to keep a running record of blood pressure and pulse at operation in all cases in order that the test may be under controlled conditions.

After these preliminary considerations let me quote cases of emergency operation and operations of election as examples. (The speaker then showed arteriograms and photographs illustrating the following cases).

(1) Papangellis (98 B.G.H.) — Operation 19 days after onset of the lesion for severe pain, femoral nerve pressure and progressive ischaemia. Direct ligation and division of artery, ligation of vein. (Photo. Arteriogram).

(2) Morwood (2 Ind.C.C.S.) — Large tense hæmatoma involving lower part of popliteal fossa. Expansion and loss of anterior tibial pulse which had been present previously. Operation at 6 weeks. Evacuation of clot and suture of artery. (Arteriogram).

(3) Pavelic (45 B.G.H.) — Huge popliteal hæmatoma. Operation at 8 weeks for flexion contracture of knee and lateral popliteal palsy. Peripheral pulses absent but fair circulation. Evacuation of clot and suture of artery. (Arteriogram).

(4) Lester (22 B.G.H.) — Very large popliteal lesion of 6 months duration. Periplural pulses present. At operation poor collateral circulation. Endothelial lined sac containing no clot. Reconstructive aneurysmorrhaphy. Peripheral pulses never lost. Arteriogram 7 weeks after operation shows irregularity of the artery but all circulation passing through the repair. B.7—3 months. (Arteriogram after operation).

(5) Stamper (33 B.G.H.) — Very large lesion popliteal. Edema of limb. Operation at 10 weeks. Varicose aneurysm. Ligation of vein above and below the opening and aneurysmorrhaphy. Peripheral pulses excellent after operation but thrombosed about 14 days later gradually. Illustrates the mistake of performing aneurysmorrhaphy except in the sacs purely derived from dilatation of the vein. Excellent circulation in spite of this. (Arteriogram).

(6) Rowse (69 B.G.H.) — Femoral lesion with apparently good collateral circulation at operation performed at 6 weeks because of pain. Direct ligation and division and paravertebral block. B.7—3 months. (Arteriogram).

(7) Littlechild (100 B.G.H.) — Large popliteal arterio-venous aneurysm of 8 weeks duration. Excision of sac and lateral suture of 3/4 inch tear in artery. Post operative deparinisation for 3 days. Peripheral pulses never lost. Letter from home — Category A.1.

(8) Bacon (2 B.G.H.) — Similar but artery and vein lying side by side. Closure of venous openings from within the sac and reconstruction of artery. Peripheral pulses never lost. Here I show popliteal thrombosis case for comparison with the arteriogram taken 8 weeks after operation. (Arteriogram of popliteal thrombosis and after operation).

### Arterio-Venous Fistulae

(1) Hatch (93 B.G.H.) — Operation at 10 weeks because of pressure on tibial nerve. Arteriogram to show the early effects of the lesion and the dangers of proximal ligation. Quadruple ligation just above and below the lesion. (Arteriogram).

(2) Bolic (11 Con. Depot) — Femoral fistula of 1 year's duration. Massive limb, pulsating veins. Enlarged heart grossly dilated vessels. Division of fistula. Lateral suture of artery



and arterialised vein. Uninterrupted recovery. (Photo, Arteriogram, Heart X-Rays painting).

(3) Kotar (45 B.G.H.) — Calcified lesion present for 2 years. Enlarged heart. Trophic changes in the limb. Excision. Complete recovery. (Photo, X-Ray Heart X-Rays).

In all 47 operations for aneurysm have been performed involving the following arteries: —

External iliac	-	-	-	1
Femoral	-	-	-	7
Lt. Fem. circumflex-	-	-	-	1
Popliteal	-	-	-	10
Post tibial	-	-	-	7
Anterior tibial	-	-	-	1
				<hr/> 27

Subclavian	-	-	-	1
Axillary	-	-	-	5
Brachial	-	-	-	4
Radial	-	-	-	1
Inf. ulnar. collateral	-	-	-	1
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Common carotid	-	-	-	1
Internal carotid	-	-	-	1
External carotid	-	-	-	2
External maxillary	-	-	-	1
Superficial temporal	-	-	-	3
				<hr/> 8

One death occurred from leaking aneurysm of the external iliac artery, and an emergency operation for leaking axillary aneurysm was followed by gangrene of two fingers. No other circulatory complications have arisen.

If we consider the main limb vessels, i.e., subclavian to brachial and external iliac to popliteal, the operations are detailed in Table 2:—

Proximal ligation	-	1	(death)
Proximal and distal ligation	-	1	(emergency for leaking aneurysm)
Direct ligation	-	13	No circulatory complications.
Arterial suture	-	7	
Reconstructive aneurysmorrhaphy	-	5	No circulatory complications.
Other repairs	-	1	

Excluding emergency cases therefore half of the cases have been treated by some form of repair.

Let us consider arterial wounds in general. Makins found that primary ligation of the popliteal artery was followed by gangrene in 41.66% of cases, the other figures being femoral and subclavian 25%, brachial 23%, and axillary 16.66%. In 310 injuries of femoral and popliteal artery gangrene occurred in 40% whereas the corresponding upper limb vessels had only 4.2% incidence of gangrene. As the artery with apparently the worst prognosis, I propose to limit my remarks to the popliteal artery, with brief reference only to the femoral artery.

Referring to the popliteal artery, Ogilvie quotes Stout as stating at a Surgical Conference in Cairo that amputation followed primary popliteal ligation in all cases and only two surgeons were able to quote cases to the contrary. Ogilvie later asserted that as the collateral vessels all traverse the popliteal fossa they are liable to compression by the hæmatoma expanding in a space relatively in elastic walls and therefore immediate operation is required in the

mæmatoma stage. It seems paradoxical to recommend a procedure which you have just declared to be a one hundred per cent failure. Furthermore, if this were true, very few cases of popliteal aneurysm would come to operation in the later stages and yet it has been the most common lesion in our small experience. It would be of interest to consider the results of treatment in these cases, for if they are satisfactory it might be worth while to modify our primary treatment and deliberately allow an aneurysm to form in selected cases.

Of the ten cases operated upon for popliteal aneurysm, excluding two cases with nerve lesions, seven have returned to duty, two in Category A, one of these a Polish Officer aged 41. The remaining case I felt required further treatment and he was evacuated to U.K. where he was given 12 gallons of petrol and six weeks leave.

It was immediately apparent that even in the treatment of long standing aneurysm, ligation was followed by loss of the peripheral pulses, whereas reparative surgery was not followed by even a transient loss of pulsation. This presumptive evidence that repair resulted in a functioning vessel has been confirmed by post operative arteriography in three cases.

It is of interest to consider the previous histories with special reference to their primary surgical treatment. Of ten popliteal aneurysms eight had no primary surgery, and in one case only the skin edges were trimmed. The remaining cases were treated by wound excision but the injured artery was not noticed, and after repeated large hæmorrhages, delayed suture of the large wound converted the lesions into an aneurysm. Of nine cases of femoral aneurysm seven had no primary surgical treatment, of the remaining two the damaged vessel was not spotted and the aneurysms were later developments. Let me repeat: 19 cases of which 15 had no primary surgery.

Only four popliteal cases operated on immediately after wounding have been seen:—

(1) Wounded popliteal space, no bleeding, some numbness of foot. After two pints blood foot warm but peripheral pulses not felt, no bleeding from small wound lower angle of popliteal fossa. Here I quote the A.F. W3118 verbatim:—

“In view of the absent pulses for immediate exploration, bleeding coming from longitudinal split in artery near its bifurcation, ligation of artery and vein.”

On admission limb survival but crippled by severe ischæmic changes. Let me repeat, foot warm, peripheral pulses absent.

(2) An exactly similar case but with external bleeding, treated by Major Blackburn by primary suture with silk. On admission a limb whose circulation was well established although thrombosis of the popliteal artery had occurred.

(3) Another similar case with external hæmorrhage with gangrene of a large area of the heel and ischæmic muscles. All these cases had had their leg fascia widely split, and later suture of the skin.

(4) The fourth case was the only really satisfactory result of popliteal ligation that we have seen.

Why do so few popliteal ligations find their way to the Vascular Centre? Is it because the results are so good or is it because they have already lost their limbs?



In 1919 Makins stated "suture of wounded vessels is the only method by which ideal results can be obtained" but he added that "primary suture was only applicable if there was reasonable hope of freedom from infection." Since Makins wrote these words a quarter of a century has elapsed; a period associated with the universal development of blood transfusion, the introduction of the sulphonamides and penicillin, the use of heparin and the surgery of the sympathetic. Surely with all these invaluable additions we should be able to produce much better results. Have we in fact done so? It is obvious that the results of primary ligation are certain to be worse than those of any other method of treatment. Are we going to view them with complacency or are we going to modify our methods. The following suggestions are made:—

*The case with little or no external bleeding.* What are the indications for primary surgery? They are (1) to exercise the wound and so decompress the tissues and prevent infection. (2) Ogilvie's view that in popliteal cases the collateral vessels are obliterated by the expanding hæmatoma; (3) early operation may mean early evacuation which may be necessary for operational reasons. Against this are (1) cases which have had no primary surgery appear to do well with the treatment of the resulting aneurysm; (2) penicillin has reduced the risk of infection; (3) Ogilvie's contention\* though in theory anatomically sound is not borne out in our experience, for in four cases of very large popliteal hæmatoma of six weeks to three months' duration the combination of blood flow through the artery and the collateral circulation has been sufficient to sustain the limb without any evidence of ischæmia.

I suggest therefore that operation should never be carried out unless (1) the vitality of the limb is definitely endangered or (2) the hæmatoma is rapidly increasing. The non-operative treatment would be (1) penicillin and local dressing; (2) posterior gutter of plaster, well padded, and leaving the anterior surface of the limb exposed and with no compression by bandages; (3) the treatment of the limb for ischæmia; (4) A.T.S., A.G.G.S. and general penicillin if indicated; (5) hold the patient for ten days if possible.

*In larger wounds with external hæmorrhage,* provided that amputation is not required because of the prolonged application of a tourniquet, the wound will have to be excised. If the arterial opening is temporarily sealed with clot or if the artery is contused but still pulsating insufflate with penicillin and close muscles or fasciæ over it and allow an aneurysm to develop. This sounds very dangerous but do the results of primary ligation not justify the taking of risks? A clean cut opening in the artery should be treated by suture whether heparin be available or not and even if it narrows the artery. A narrow vessel is better than none at all.

If the artery be badly lacerated ligation will be necessary unless it should be possible to adopt the "no suture method of venous grafting over vitallium tubes" introduced by Blackmore, Lord and Steffen. To be of any value this would necessitate the development of a vein graft bank and the use of heparin on the grand scale.

If ligation has been carried out, replace blood loss fully and treat the limb for ischæmia from the beginning.

## SUMMARY

(1) In extensive arterial wounds the "no suture" vein graft offers new possibilities of success.

(2) If the wound has been explored and a clean cut injury found suture even without heparinisation gives better results than ligation.

(3) Always examine wounds in the region of main vessels with care. Never excise them as a routine just because they are wounds.

(4) Treat the arterial hæmatoma conservatively in the absence of definite indications for operation.

(5) Always examine such wounds with a stethoscope before carrying out delayed suture and never explore them with the finger.

(6) In all cases treat the limb as though it were ischæmic.

(7) Never operate on an aneurysm, except in emergency, until all wounds are healed and the collateral circulation has had time to develop.

(8) Estimate the collateral circulation, and if deficient carry out some form of reparative surgery no matter how difficult it may be.

(9) Examine the aneurysm with great care at operation lest any venous communication or branch vessel be missed.

(10) Intrascapular repair is a relatively easy and a very satisfactory operation in aneurysmal varix. Never use the wall of a false aneurysm as a flap for direct repair.

(11) Never excise the wall of a false aneurysm as it will only impair the collateral circulation and it is absorbed if left alone.

(12) The indications for operation on an arterio-venous fistula are more often general than local. Never carry out proximal ligation.

(13) Always remember that no matter what operation you carry out it is only an important incident in the treatment.

Here I leave the subject in your hands for discussion but would like to conclude by reading you an extract from a letter received after this paper was written from a senior member of the Vascular Subcommittee of the Medical Research Council—"If you could only get your forward surgeons to auscultate the wounds and if a murmur is present, not to excise them, you would get many more aneurysms and fewer ligations in the forward area and therefore fewer amputations." It may be that there is a place for the segregation of these cases in special forward centres in the same way as Neurosurgical and Maxillo-facial cases are treated at present.

I should like to thank Brigadier Edwards for the interest he has taken in the formation of the special centre from scratch and for his help and encouragement. The work could not have been done without the generous help of the Resuscitation staff of the hospital and of the pathologist and anaesthetist, and I should like to record by grateful thanks to them all for the extra work they have done.

My thanks are due also to all those surgeons who have referred cases to the Field Centre and I have here a list of cases and if anyone wishes to ask further about their cases I shall be very pleased to answer queries at any time during the Conference.

*Brigadier Stammers.*—Col. Mason-Brown's paper has given us food for a great deal of thought and I think by the end of this meeting we shall have much clearer ideas. I will now call upon Major Clarke.



# FORWARD SURGERY OF INJURIES TO MAJOR BLOOD VESSELS

by

Major RUSCOE CLARK, M.B.E., RAMC

## Introduction

The treatment of every significant wound of a major blood vessel includes: early exploration, clean excision of the injured portion of the vessel, and ligation or repair.

It is my intention to give a brief account of my reasons for making so dogmatic a statement.

The official "History of the Great War (Medical Services — 1922)" included a number of rules for the treatment of vascular injuries, the fourth of which reads as follows:

"When evidence exists that a large vessel has been wounded in the course of a track traversing the body or limbs, *unless the conditions are favourable* it is not advisable to interfere primarily, if no signs of progressing hæmorrhage are forthcoming, or if there are no indications that the vitality of a distal portion of the limb is becoming endangered.

In all such cases, although an arterial hæmatoma and subsequently a false aneurysm result, yet the later treatment of either of these conditions *in favourable conditions* for operation is to be preferred to the risks attendant on a primary operation in the front line.

It is obvious that the fourth rule is open to variations *under favourable conditions*; but even if a large primary hæmorrhage has taken place, an expectant attitude is better for both the immediate and remote nutrition of the parts supplied by the wounded vessel".

The problem facing the forward surgeon of today is essentially that of deciding how far this attitude still holds good and in particular what exactly constitute "favourable conditions".

## Complications of Vascular Injuries

Before considering the specific problem outlined above, the rationale underlying the plea for early definitive surgery will be reviewed.

Firstly, early exploration, with excision of all dead or damaged tissue, full hæmostasis, adequate drainage and relief of tension, is in line with our re-established principles for the treatment of all war wounds. This constitutes the basis of our attempts to prevent infection in general and gas gangrene in particular. Variation from this procedure in the case of wounds involving particular structures must be based on solid evidence that such variation is justified by results.

Secondly, there are a number of specific major dangers associated with vascular injuries, the prevention and treatment of which consists, in my opinion, of adequate forward surgery.

These specific dangers are:

- (1) Hæmorrhage
- (2) Aneurysm
- (3) The effects of interference with the circulation.

In the presence of adequate transfusion facilities and where technical difficulties are not insuperable, the best treatment of hæmorrhage involves direct control of the source of bleeding. It is equally true that ligation of a cleanly divided vessel is unlikely,

in the absence of infection, to be followed by aneurysm. The main controversy centres, therefore, around the best methods of avoiding the effects of circulatory interference.

In considering the individual case all possible dangers must be considered simultaneously. In order more clearly to define the issues at stake, I shall briefly discuss the possible complications separately.

### (1) Hæmorrhage

The older classification into "primary, reactionary and secondary" is quite inadequate. Severe bleeding must be considered in terms of the exact local and general conditions that allow it to occur. The classification adopted is used solely as a convenient method of discussing the present problem.

(a) *Primary External Hæmorrhage.* This is initially the concern of those responsible for first aid.

Every patient who has sustained a severe primary external hæmorrhage from a wound, must be regarded as a candidate for priority surgery.

(b) *Primary Bleeding into the Tissues.* The presence of blood clot and diffuse extravasation make adequate surgical exposure difficult, but these are the very conditions which produce tension, and predispose to infection and gas gangrene. Further, such tension exerts direct pressure on the collaterals, and clot around the main vessels may be contributory to the onset of vascular spasm.

The presence of tension in a limb is an absolute indication for primary surgery, all the more so where damage to a main vessel is suspected, even in the absence of interference with the peripheral circulation.

(c) *Hæmorrhage at Operation.* Severe bleeding from main vessels may be encountered during wound exploration without any previous evidence of major vascular involvement. It is especially likely to be dangerous and difficult to handle at the root of the limbs.

(d) *Delayed "Primary" or so-called "Reactionary" Hæmorrhage.* Bleeding coming on several hours or days after injury or operation may be due to an increase in blood pressure associated with recovery from "shock," to a relaxation of arterial spasm, to excessive movement in a restless patient, to the added trauma of an ambulance journey, to the erosion of a vessel by a foreign body, or very rarely to the slipping of a ligature. The greatest danger exists where operation has been performed and the site of a major vascular injury not discovered. When bleeding is stopped by packing it may start again when the packing is removed.

(e) *"Secondary Hæmorrhage."* Bleeding resulting from any of the factors described above must be distinguished from the classical "secondary hæmorrhage" associated with, and largely resulting from infection.

(f) *Hæmorrhage from Aneurysm.* Bleeding from rupture of an arterial hæmatoma may occur at any time. It is more likely where the lesion is placed at the bottom of an unhealed wound.



## (2) Aneurysm

Up to the present time the fact that traumatic aneurysms can largely be prevented by effective primary surgery has been insufficiently stressed.

It must be pointed out that the development and treatment of established aneurysms particularly at certain dangerous sites, is associated with a considerable risk of increasing interference with the peripheral circulation. This risk, involving the possibility of late loss of a limb, must be remembered in assessing the value of early exploration of arterial hæmatomata.

## (3) Interference with the Circulation

Interference with the circulation following vascular injuries may result in necrosis and tissue death ranging from the discoloration of the tip of a toe to gas gangrene of a whole limb. The effect on various tissues depends largely on the duration and degree of oxygen deprivation in relation to local metabolic needs. Permanent damage to nerves may result from cutting off their blood supply for from 15 to 30 minutes.

Muscles are less susceptible, but after 8 hours' inschæmia, contracture may develop. Skin can survive 24 to 36 hours' severe circulatory deficiency with a good chance of recovery. Tissue metabolism is increased by heat and movement, and decreased by cooling and immobilisation.

The result of interference with the circulation in any given case will depend on a number of factors, in addition to time and the requirements of tissue metabolism. These include:

- (a) Site of vascular injury
- (b) Extent and (duration) of interference with collateral circulation.
- (c) The pre-existent vascular anatomy
- (d) General condition of blood and circulation.
- Quite apart from:
- (e) Pre- and post-operative treatment and
- (f) Surgery

Differences of opinion still exist as to which of the main vessels may be safely ligatured. Grey Turner, discussing war wounds in the *British Encyclopædia of Medical Practice* (Medical Progress 1944), states (2).

"There is now enough experience to guide us in saying that it is necessary to consider repair of the vessel wall by suturing, only in dealing with the common carotid, the common iliac, and the popliteal vessels".

I would add to this the common femoral artery at the level of its bifurcation. Other surgeons report unfavourably on the chance of survival of a limb following injury to subclavian and axillary vessels.

It is again worth stressing that anærobic myositis is a disease of devitalised muscle and that major vascular injuries frequently produce gas gangrene of a fulminating type.

In considering the causation of gas gangrene as of all the other effects of interference with the circulation following vascular injuries, the state of the collateral circulation is at least as important as the site of injury. It may be the chief consideration in treatment in forward areas. It is particularly important in the calf with reference to gas gangrene, and at the elbow and in the axilla with reference to ischæmic contracture.

*Collateral Circulation* may be interfered with by:

(a) *Direct trauma* as in a single massive soft-part wound or in multiple wounds.

(b) *Operative Trauma*.

(c) *Extension of thrombosis*: This is most dangerous where a main vessel is contused or lacerated at the level of vital collateral branches.

(d) *Embolism*. In addition to the spread of thrombosis from the site of injury, further circulatory inadequacy may result from embolism originating from this thrombosed area. This risk will be minimised by early ligation of both ends of vessels after removal of injured segments.

(e) *Pressure* from continue bleeding or serious oozing into confined undrained fascial spaces, or when packing is used to arrest bleeding, is an additional factor affecting the functioning of the collateral circulation.

(f) *Spasm*: The role of arterial spasm in increasing the danger of circulatory deficiency following vascular injuries has become increasingly recognised in recent years in connection with ischæmia and gangrene following closed fractures.

Until recently spasm has been regarded as one of the essential parts of the mechanism for the control of bleeding from major blood vessels. A study of the histology of cross sections of large arteries that have been divided and have ceased to bleed spontaneously, suggests that where the vessel is damaged by a missile no such clear cut process as we had imagined takes place and that often *thrombosis* alone, without either spasm or retraction of the intima, results in arrest of hæmorrhage.

Cohen (3) makes it clear that the part spasm plays in circulatory deficiency is still incompletely understood.

There is no evidence of a clear-cut sympathetic reflex arc that can be broken by attacks on the sympathetic, and the results of novocaine injections and sympathectomies of various kinds are difficult to evaluate.

Barnes and Trueta (4) produced spasm in their experimental animal spreading even to involve the opposite limb, by application of a tourniquet. They were unable to get evidence of any constant effect of sympathetic block.

Spasm, local or widespread and varying in duration undoubtedly results from arterial trauma. We do not know exactly what is the mechanism producing it. It appears to be relieved clinically by various types of procedure ranging from the division of an overlying layer of fascia to resection of a segment of injured artery. Too little is yet known of the results of operative intervention for spasm, however, for any firm conclusions to be drawn.

Many surgeons adopt a conservative attitude in certain types of vascular lesions. In some injuries to main vessels, particularly with a lateral tear, the circulation through the vessel may be maintained in the presence of an arterial hæmatoma. It is possible that where the "dangerous sites" are affected, there are cases where conservative treatment allows collateral circulation to be established before thrombosis is complete or secondary interference for aneurysm required. There are undoubtedly other cases where early exploration and ligation give the best chance of survival of the limb. In all cases the risk of infection and gas gangrene after inadequate



exploration must be born in mind. I cannot see how we can know in advance which method of treatment is likely to give the best result in an individual case. It is generally agreed that surgery is indicated where there is already evidence of circulatory deficiency beyond the lesion. The presence of a good peripheral pulse and full movement is, however, no certainty that spasm or thrombosis will not produce gangrene later.

The final appeal can only be made to the results actually obtained, which, however, are as yet not forthcoming in this war. Meanwhile, as doubt exists as to the best treatment, it would be logical to evacuate hæmatomas, relieve tension, and excise damaged vessel segments.

A further argument put forward against the general advocacy of radical surgery in these lesions is that the operations themselves are frequently dangerous and technically difficult. Surgeons have at times been forced to compromise by packing wounds to stop hæmorrhage without dealing directly with the vascular injury. This procedure reproduces most of the original conditions of tension and lack of drainage, which forward surgery seeks to avoid and thereby invites sepsis and secondary hæmorrhage. The easiest time to carry out a proper exploration and secure bleeding vessels is at the original operation.

I have seen recently two cases of severe ischæmic contracture following the arrest of venous bleeding in the axilla by packing, where it was clear that the incision was inadequate to allow full access to the site of bleeding.

There are undoubtedly, circumstances where the general condition of the patient and the anatomical set-up make packing the only method of saving life. The use of packing must, however, be regarded only as a last resort.

### Technical Difficulties.

The alternative procedure advocated involves full exposure and review of the damage to the vessels. This will be followed in most cases by resection of the injured portion of the vessel and gentle ligation of the cleanly divided ends.

Whenever possible these operations should be completed or at least begun without a tourniquet. Firstly, because the tourniquet may further endanger an already imperilled circulation; and secondly, because with a tourniquet in place it is more difficult to distinguish between viable and non-viable muscle.

It is essential that the incision should be adequate, for its length is of no great concern, now that delayed primary suture has become an established routine. It should not traverse flexion creases at right angles, as this predisposes to a crippling scar.

In most cases it is possible to use some modification of the classical exposures of the main arteries. These, however, are much easier in theory than in the presence of large quantities of extravasated blood. The key stage of the operation is the division of the fascial layer immediately covering the vessel. In many cases the hole in this fascia traversed by the missile will act as a guide, and this can be rapidly enlarged with blunt-pointed scissors by feel alone, even where active bleeding is taking place. It is hopeless to attempt to find the bleeding vessel until this fascial covering is adequately divided.

When this has been done, it is frequently possible by the use of digital pressure over a swab in the corner of the wound to control bleeding sufficiently to get a view of the nature and site of injury. The vessel can then be separated from adjacent nerves and fascial attachments before resection and ligation.

Only if such methods have failed to allow visualisation or where bleeding is dangerously severe, should a tourniquet be applied. Even then, it should be taken off as soon as possible.

### Suture Material.

For ligation of large arteries, I have found size 60 thread to be completely satisfactory, preferring it to catgut. Ligatures of large vessels should be tied gently so as not to cut into the vessel. The use of a relatively fine cotton, thread or silk makes it impossible to tie too tightly. I have used a single tie of this same material for all forward amputations and have never had any cause to regret it.

These general remarks can best be amplified in terms of lesions at special sites:—

*The Calf.* The posterior tibial vessels are probably more commonly injured than any other vessels in which a wound may be dangerous to life. Injuries to the calf are notoriously liable to develop gas gangrene, particularly where primary surgery is inadequate or delayed much over 12 hours. Calf injuries with any degree of tension or external bleeding are now regarded as surgical priorities.

The initial practical difficulty is that of deciding whether or not any formal exposure of the posterior tibial vessels is indicated. Where the wound is placed posteriorly in the midline such formal exposure may be obtained by enlarging the original wound. Where the wound or wounds are placed more laterally a decision must be made at an early stage as to whether adequate exposure can be obtained by an elongation of the incision necessary for preliminary exploration. If this is considered impossible, a fresh incision should be made and the deep vessels exposed along classical lines. In no case is it wise to look for the posterior tibial or peroneal vessels by ploughing through muscle, and the fascial plane deep to the soleus must be defined before the main muscle mass is divided. In the absence of signs of circulatory inadequacy, pulsating hæmatoma, severe external bleeding, blood clot in the wound track or an unusual degree of swelling, adequate wound toilet may be possible without formal exposure of the main vessels. The above conditions, however, are absolute indications for visual examination of these vessels.

In the upper part of the calf it is frequently difficult to decide whether the injury involves the popliteal vessels or their terminal branches or tributaries. Both may be injured simultaneously some distance apart. Extensive division of individual muscular branches at this level may result in ischæmic contracture or gas gangrene without division of the main vascular trunks. Care must be taken to avoid further injury to significant vessels that have escaped injury.

Finally the anterior tibial vessels may be the only source of bleeding into the popliteal fossa. Exposure in the region of the foramen above the interosseous membrane can be difficult. Deep packing at this site may interfere with circulation through a previously intact posterior tibial vessel. It is at this level, moreover, that the anterior tibial



vessel is likely to be damaged in association with a fracture of the upper end of the fibula. The best approach is from the outer side of the limb by resecting the upper end of the fibula and retracting the peroneal nerve. This is simpler than temporary dislocation of the divided upper end of the fibula advocated by Fiolle & Delmas (5) and preferable to the method suggested by Henry (6) which involves deliberate division of a sheaf of vessels in the anterior compartment. I have seen one case where gas gangrene limited to the anterior group of muscles followed the overlooking of an injury to the anterior tibial artery at this level.

#### *Popliteal Vessels.*

Surgical approach is usually relatively straightforward. Vertical incisions across the flexion crease must be avoided and oblique or Z-shaped incisions substituted. Where it is uncertain whether the injury involves popliteal or lower femoral the oblique posterior-medial approach described in Hamilton Bailey's War Surgery (7), which enlarges by division of fascia or muscle the hole in the Adductor Magnus, gives an excellent approach.

There still exists widespread pessimism about the chance of retaining a limb after damage to the popliteal artery. It was asserted at a Middle East conference (8) a few years ago that preservation of the limb was almost unknown after ligation of this vessel in forward areas. I have personally ligatured three popliteal arteries in forward areas with no subsequent suspicion of vascular insufficiency. Clearly the outcome is dependant on a number of factors, but I am convinced that adequate early exploration and definitive treatment of the vessel lesion gives a better chance than any policy of non-intervention.

Severe interference with the circulation may result here as elsewhere from injury to the vein alone where the popliteal fossa becomes full of blood under tension.

#### *The Root of the Neck.*

One of the most dangerous sites of vascular injury is the root of the neck where common carotid, or subclavian arteries and their main branches may be involved. Here again a large hæmatoma may result from venous injury alone. Given adequate transfusion facilities I believe these injuries should be explored in forward areas with a view to definitive control of the site of bleeding. This cannot be done in the lower part of the neck with any degree of safety with the clavicle in position. The most rapid exposure is obtained by resection of the inner half of the clavicle, rather than by previously advocated methods involving its division and preservation of the reflected portion with muscle flaps. Resection is particularly necessary where a comminuted fracture overlies a large arterial hæmatoma. The clavicle should be removed if possible before the hæmatoma is disturbed.

In the *Upper Part of the Neck* severe vascular injuries are often associated with injury to pharynx or trachea and a tracheotomy under local anaesthesia may be necessary before the operation is begun or any form of anaesthesia started. Passage of an intra-tracheal catheter may otherwise be followed by uncontrollable hæmorrhage and immediate asphyxia. Cases of the type are seldom fit to evacuate, and their only hope of survival may depend on bold primary surgery.

*Superior Gluteal Vessels.* Wounds of the buttock are dangerous from many points of view. Here again, where during the course of a wound exploration, a deep hæmatoma or severe bleeding is encountered, every effort must be made to visualise the source of the bleeding and control it by ligation. In order to do this it will usually be necessary to split the fibres of the gluteus maximus along their length.

Even when full exposure is obtained of the site of emergence of the gluteal vessels from the greater sciatic notch, it may be discovered that the vessels have been injured inside the pelvis. It is tempting under such conditions to resort to packing. This, however, may merely hide the fact that bleeding into the pelvic cellular tissues and retro-peritoneum is uncontrolled. I have seen one fatal case where death resulted from such bleeding from a divided superior gluteal vessel. Ligation of the internal iliac has little effect owing to the free anastomoses across the pelvis. Where packing is temporarily successful the problem will be no easier to cope with if bleeding recurs. Direct exposure of this region from above is almost impossible in the male, and likely to be complicated by venous bleeding from internal iliac plexus. It might be wiser in such cases to attempt direct exposure by resection of a portion of the sacrum as in the Kraske operation for conservative resection of the rectum.

*Internal Mammary Artery.* This vessel is liable to be damaged in wounds near the sternum or costal cartilages. Severe intra-thoracic bleeding may result in a hæmothorax that is difficult to control by aspiration, or a troublesome external secondary hæmorrhage later may require a difficult operation across a septic granulating wound.

It is now generally recognised that wounds of the chest wall should be excised as thoroughly as wounds of the limbs. No exception should be made in cases where the sternum or cartilages are involved and a damaged internal mammary should be ligatured during the course of this procedure.

*Ancillary Methods of Treatment.* A number of adjuvant methods are often used, the value of which remains questionable.

(1) Ligation of the vein accompanying a damaged main artery as first proposed by Makins. I cannot see that increasing venous pressure in the tissues can possibly have any prophylactic value. Ogilvie maintains that the same effect may be obtained by posture. I doubt if the effect is really desirable and suggest that a moderate degree of elevation of the affected limb is more rational.

(2) Antispasmodics: Various substances like Papaverine have been used in an attempt to counter the effect of vascular spasm, but there is but little to commend them.

(3) Sympathetic Block and Operations upon the Sympathetic: These are based on the theory that vascular spasm is due to a reflexly induced hyperactivity of the sympathetic. There is no direct evidence of any such reflex. There is accumulating evidence that the sympathetic can produce both vasoconstriction and vasodilatation in the same set of vessels, and varying effects at the same time in different vessels, dependent on pre-existent local conditions and central nervous activity.

The chief available clinical evidence is that sympathetic block can induce cutaneous vasodilatation.



It is possible that this results in a shift of the available blood into the cutaneous circulation and increases the threat to the less resistant muscles. It is extremely difficult to judge clinically the effects of sympathetic interference, and I believe that until we know a lot more about the whole matter we should abandon such procedures.

(4) Heating of the involved limb is mentioned only to be dismissed. Warming of the unaffected limbs has been suggested as a means of obtaining retraction of spasm in the affected one, but I am very doubtful if this occurs.

(5) Splitting the Fascia: Where tension is actually present, decompression by fascial splitting is indicated, I am not convinced of its value where no tension exists.

(6) Evacuation: If the military exigencies allow, cases of vascular injury should be held in forward areas until the period of danger has passed.

### Conclusion

In view of the nature of the technical difficulties, it is easy to understand an inexperienced surgeon adopting a conservative attitude to severe vascular injuries where immediate surgery is not obviously demanded. In certain situations, such as the neck or axilla and where there is no evidence of peripheral circulatory inadequacy, there is no harm in waiting even a number of hours if in this way better facilities or a more experienced surgeon can be available. Given full transfusion facilities, good lighting, X-rays and a surgeon with reasonable ability to deal with injuries of this kind there is no reason for not operating on all these cases in forward areas.

It requires, however, much more than the experience of any single surgeon to produce final proof of the correctness of this statement. If we consider, for example, only the vascular injuries at a single site, innumerable variables make crude statistics valueless. Study of large groups of cases observed under modern conditions is required. It is particularly necessary to have details of the extent of the original injuries and the exact nature of the operation performed. Nothing short of the detailed study of the work of a whole army in action over a period of months can begin to provide any answer. In awaiting such a study under modern conditions I suggest that the treatment of all vascular injuries be brought into line with the treatment of all other wounds, *i.e.*, that full operative exploration, with removal of dead and non-viable tissue, hæmostasis, relief of tension and drainage where necessary be regarded as the objective. Such definitive surgery to be carried out in the forward areas and followed by minimal evacuation, slight elevation and cooling of the limb, and careful observation and note taking.

### Reconstructive Surgery

So far I have not entered into any discussion of the place of reparative surgery in these major vascular injuries. Reports in the British literature of cases of primary arterial suture have been disappointingly few, although a number of attempts have

been made by individuals with varying degrees of success. Even in the absence of heparin it would appear probable that a number of limbs could be saved by end-to-end suture in injuries at certain sites. The more frequently full exploration is carried out, the more often will the opportunity for suture arise. It may be absolutely indicated where popliteal, external iliac or common carotids are divided and there are signs of peripheral circulatory failure. Where distal pulsation is present or warmth and movement of a limb are normal, it must be realised that there are risks attached to suture that may be minimised by ligation. If thrombosis does occur rapidly at the site of ligation it may spread to involve functioning collaterals or give rise to emboli.

Where the circulation is already threatened and substantial defects are present in the injured main vessels, other methods for temporary restoration of continuity may be worth employing. Those suggested include venous grafts and vitallium tubes lined with venous grafts.

Without suggesting the suturing of every divided main vessel, I believe that the possibilities of primary reparative surgery should be born in mind by all forward surgeons.

### Summary

A plea is made for full exploration and excision of damaged tissue in all injuries to major blood vessels. A large proportion of aneurysms and hæmorrhages will be completely avoided. The dangers of gas gangrene will be decreased considerably and, in my opinion, the chance of survival of the limb will be increased. It is felt that the somewhat cautious attitude advocated by those who summarised the history of the last war should be revised. The favourable conditions mentioned in my opening paragraph include full transfusion arrangements, good lighting, adequate nursing and X-rays. These should exist at the advanced operating centre or casualty clearing station, and exploration must be carried out in every case at this level.

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*Brigadier Stammers.*

We have now heard a surgeon from forward areas giving identically opposite views from those of the opener. I will now call upon Major Erasmus.



## THE PROBLEM OF WOUND EXCISION IN THE TREATMENT OF VASCULAR INJURIES

by

Major J. F. P. ERASMUS, SAMC

During the past six months or so 587 limb wounds (exclusive of wounds of the hand and foot) have been operated on at the 8 (S.A.) C.C.S. About two-thirds of these reached the C.C.S. as Priority 3's. Table I indicates the incidence of arterial lesions in this series, and also includes, for the sake of completeness, 30 wounds of the neck.

**TABLE I**  
**Major Arterial Injuries**

Site of Wound	No. of Cases	No. with Arterial Injury	No. with amputation for Arterial and Other Injuries
Delto-Scapulo Pectoral	73	1 (1.4%)	0
Upper Arm. . .	74	2 (2.7%)	1
Forearm . . .	92	7 (7.6%)	0
Thigh. . . . .	165	7 (4.2%)	2
Popliteal Region.	34	6 (17.6%)	2
Leg . . . . .	149	17 (11.4%)	2
Total Limb. (Excluding hand and foot.)	587	40 (6.8%)	7
Neck . . . . .	30	2	

A number of limb wounds have exhibited arterial lesions associated with other gross injuries, such as very extensive muscle, bone and nerve injury. In this group the vascular lesion has given one, though only one, of the indications for amputation. These cases need no further mention.

Let us consider the remaining 35 cases. In one case the patient, a sepoy, came to the operating room with a cold, pulseless upper limb and a through-and-through wound of the upper arm. Wound excision and exploration revealed a state of spasm in the brachial artery. Periarterial sympathectomy was performed, the radial pulse became palpable eight hours after operation and the patient was evacuated 36 hours after operation with an apparently normal circulation. I have seen six similar cases in the past, some months after injury and they have all exhibited some degree of ischaemic contracture; five involved the brachial artery and one the popliteal. I feel that if something had been done for these cases in an earlier stage they might have been spared much misery. These soldiers were all wounded in the Western Desert and Alamein battles, and at that time the "official" policy seemed to be to leave lesions alone if possible. It is well to bear this in mind.

**TABLE II**  
**Arterial ligatures (34 cases)**

GROUP A <i>As Life-Saving Operation</i>		GROUP B <i>As part of Wound Excision</i>			
Artery		Total No.	With Muscle Damage	With Joint Injury	With Fracture
Subclavian . . . . .	3	0	—	—	—
Radial or ulnar . . .	0	0	1	1	3
Radial and ulnar. . .	0	1	1	0	0
Femoral . . . . .	0	5	5	0	0
Popliteal. . . . .	1	3	2	2	0
Anterior or posterior tibial . . . . .	0	14	9	0	5
Anterior and posterior tibial . . . . .	0	1	1	0	1
Total	4	30	19	3	9

We are now left with 34 arterial injuries treated by ligation, with or without planned decompression. The first indication for ligation is an immediate or early attempt to save life. Severe, active hæmorrhage obviously calls for ligation. In the present series only four such cases were encountered. In one the third part of the subclavian artery was tied with success, two other soldiers with subclavian arterial tears died on the table. In one case severe hæmorrhage (internal) necessitated life-saving ligation of the popliteal artery.

We now find that in 30 cases (Group B of Table II) there was no immediate indication for ligaturing arteries. How did they come to be tied? The story is more or less the same in every case. Wound excision is carried out on a limb, which may or may not appear swollen, the deep fascia is split and slit up, and then, or when muscle excision is commenced, there is a gush of blood which washed away clot and torrential hæmorrhage follows. There is now only one thing that can be done, the bleeding must be stopped, and this involves tying the artery.

The question that now arises is an important one. Should we leave these limbs alone? This must surely depend on a number of factors: on the extent of muscle damage, on the presence of joint and bone injury. An analysis of the present series has shown that in only eight cases have there been no associated serious injury to these structures. It must surely also depend on the vessels involved. There can surely be little harm in tying one of the arteries of the forearm or leg—there may be harm done if a growing hæmatoma compresses the second main artery. Having to tie both is a grave matter, and here I wish to mention the case of a through-and-through wound of the leg in which wound excision by

another surgeon ended up with ligation of the anterior and posterior tibials. I amputated the leg 36 hours later.

When it comes to tying a single main vessel the matter becomes a serious one. The popliteal is the real bugbear, and the series contains one popliteal hæmorrhage encountered during the course of wound excision and with relatively little muscle damage and no joint involvement.

Unfortunately, we have no means of assessing the amount of muscle injury in a limb until we see the muscle. Bone injury we can detect by X-ray. Joint involvement can be assessed from X-rays. So that if we do not excise wounds in the presence of major vascular damage we may leave behind a large mass of devitalised muscle which can do no good. The site of the wound in relation to the position of the M.F.B. may help in assessing the probable extent of muscle injury.

If there be no bone or joint injury, and probably no serious muscle injury, it may be advisable not to excise a wound when one of the arteries (certainly of the principal single arteries) is injured. The case may do better if we allow the hæmatoma to develop into a traumatic aneurysm.

This requires:—

(1) Holding at least at C.C.S. level for perhaps a week or ten days.

(2) Constant alertness in guarding against a second severe hæmorrhage.

## Discussion

*Major McDowell.*

On the night of 4th June this year I was temporarily attached to an operating C.C.S. On that evening some vascular injuries came under my immediate care. I will describe three cases to give an idea of the type of work which confronts us. The first case was a wound of the leg just above the knee. Entry wound was on the lateral side and there was no exit. There was no posterior tibial pulse. The limb was cold, and in my opinion the wound needed to be explored. Obviously the popliteal vessel was injured, so I did not follow up the wound track, but made an incision in the midline at the back eight inches long down to and including the calf, to remove the blood clot. I may say I had a tourniquet ready if necessary. When I removed the last clot, arterial hæmorrhage gushed forth. I had to tighten up the tourniquet. The nerve as intact and the vein was intact, but the popliteal artery was completely severed. I obviously had to ligature it. Contrary to what we have heard this afternoon, I put the limb with about 30 degrees flexion of the knee-joint in a Thomas' splint. I put the man to bed, allowed the limb to be uncovered by bedclothes, and put him on a five-day course of parenteral penicillin. On the fifth day the case had to be evacuated. Since coming to this meeting, one of the surgeons from the base hospital tells me that delayed primary suture was done on that limb, and the limb, as far as he knows, is all right. I maintain that you have to explore the wound to find out what the damage is, and to relieve tension. A second case was that of a through-and-through wound of the left shoulder. The wound was full of blood clot. The question was: should I leave it alone or not because the radial pulse had gone? The limb was not very cold, but colder than the other arm. The wound track went in front of the humerus towards the axilla, obviously in the line of

the axillary vessels. Arterial hæmorrhage started, and was rather severe. I put on a tourniquet and digital pressure was applied to the subclavian artery. I had great difficulty in finding a tear in the artery, so I did a proximal ligation of the third part of the axillary artery just below the clavical. I then took my finger off the subclavian to see what would happen, and no bleeding took place. I excised the entrance wound, took out the missile, and eventually sent him to the vascular centre. I received a reply a week ago stating there had been slight sepsis, but the shoulder had healed within three weeks, after having been sutured. A third case was of a wound of the leg which had severed the anterior tibial artery. A track had gone downwards shattering the fibula. The foreign body was then removed. I ligatured the artery and excised most of the damaged muscle, left the wound wide open, and gave him a five-day course of parenteral penicillin, and he did well. These three cases illustrate the type of problem you get in forward areas. I cannot claim to know enough about vascular surgery to say anything except that vascular lesions should be treated early, for in that way you are much less likely to get gas gangrene.

*Major Rob.*

Having recently returned to the base from a forward area, I have seen both ends of the problem. I would like to mention two points. Firstly, Major Clarke says that gas gangrene is bound up with the conservative treatment of hæmatoma. I know few factors more likely to produce gas gangrene than arterial ligation. Secondly, the selection of cases for conservative treatment. I can remember several cases of small wounds on which I operated and was confronted with torrential hæmorrhage as a result of the operation, and ligated the artery. I now know that I could have treated these cases conservatively and let an aneurysm develop with the result that the patient's limb would probably have been saved.

*Major Cleland.*

I have been faced on many occasions with these problems as a forward surgeon dealing with serious vascular lesions. I agree heartily in general with what Major Ruscoe Clarke says. I say specifically "in general," for I feel that in the type of vascular injury we see, it is necessary to explore in a large proportion of cases. It is often the case that when a vessel is found to be completely divided, a large area of thrombosis extends considerable distance. Certain cases have spasm—pure spasm. I would not be prepared to say whether I am right or not, but I tend to the view that thrombosis is likely to follow that spasm. I have also seen penetrating wounds of the popliteal fossa which I have treated by exploration and ligation, which in view of what Colonel Brown has said, I would now be prepared to leave alone. I think nobody can lay down specific rules as to what is to be done in these cases, and in view of the excellent results which are being obtained as a result of conservative surgery in the type of aneurysm which has been described, we should be more alive to the possibility that certain wounds can be dealt with conservatively. The decision will often be difficult and we may do wrong, but I think we should bear in mind that those cases described have on the whole been relatively small wounds.

I just want to say a word about decompression. I had an interesting observation in relation to an



Italian caught up in a cement-mixing machine. He sustained a fractured humerus and crush injuries, and his arm was pulseless. I explored and found an area which was contused. I removed that area and I proceeded to divide the fascia in much the same way as advocated by many people. Within four minutes of doing that, my orderly announced with great glee that warmth was returning to the hand. I have noticed pale swollen muscle in the fore-arm regain colour and literally regain contractility before my eyes.

*Col. Lichtenstein*

I want to express appreciation for the invitation to attend these meetings.

This discussion on vascular surgery has been very interesting. In connection with the two interesting papers, one by Colonel Mason-Brown, the other by Major Clarke, it appeared to me that they were not so opposed to each other as they seemed to indicate. It has been my experience in seeing injuries to vessels that patients with popliteal injuries, or injuries to the other vessels, were sent back under the categories of either chance or design. By chance, I mean injuries to vessels overlooked at the time of original injuries to the limb. These are small holes one does not seek for, small wounds that do not require extensive exploration. Characteristic signs do not develop until several days have elapsed. These are picked up and sent to general hospitals in the rear, and operated on at a time when no danger to the vitality of the limb exists.

The second type being sent back to the rear are classified in my opinion as sent back by design. This group shews the presence of arterial injury, but the limb does not demonstrate any evidence of having the blood supply impaired. There is no tension, no swelling and not much tenderness. The patient is kept in a forward hospital for several days for observation to rule out the prospect of any occurrence of gangrene. These patients are adequately immobilised and sent back to the rear. On the other hand, some patients demonstrate evidence of tension in the limb. Where there is a prospect of further damage occurring to the limb by reason of internal hæmorrhage we explore.

The reason for my first remark on the two papers is that I don't believe that the two officers were really describing the same type of case. If both had been looking at the same cases, it is very likely that both of them would have come to the same conclusion, and that the indications for immediate exploration as they were presented by Major Clarke would have been used by Colonel Brown.

In this discussion I was hoping that something would be said about carotid arteries. I have had experience of six cases of injuries involving the carotid. It would be interesting to learn what the incidence of injury to this artery is. I am hoping to get some information from Colonel Brown on that subject.

*Major Benison*

I would like to disagree with my friend Major Rob who said that ligation is one of the main causes of gas gangrene. The problem is often a large hæmatoma involving muscle which is likely to become affected by gas gangrene, and this gives rise to filling up a form which we all wish to avoid! I think it wrong to say that ligation of the artery is the main

cause of gas gangrene in a large number of cases. There is obviously a middle course we ought to pursue in the treatment of arterial injuries, but I know the last speaker was a little wrong in saying that both Major Clarke and Colonel Brown would treat the same case in the same way. Clearly there is a middle course where some cases can be left and some dealt with in the forward areas, but it is obviously better to be measured for an artificial limb than to be measured for a coffin.

*General Mitchiner*

Speaking as one of the discredited surgeons of the last war, I have some experience of vascular surgery in the forward areas of Yugo-Slavia.

In regard to immediate surgery, I would say that in my experience any limb which is devitalised where the pulse is not palpable needs forward surgery in every case. When we do that surgery, we want to make an incision three times as long as we think we are going to need.

If the wound has to be packed I think the surgeon had better revert to gynaecology or psychiatry, and secondly, he may just as well amputate that limb straight away as to try and arrest hæmorrhage by packing. Incidentally, in these cases of arterial wounds no one has mentioned the persistently rapid pulse of 100/120, which in the absence of gas gangrene always indicates a leaking artery. Where there is leaking, I have no hesitation in saying ligation is indicated.

When I returned after the last war I was able to follow up several cases on which I had done repair operations. Several had had thrombosis, but had all good results. I think if you follow up repair operations very carefully for five or six years, you will find that a certain proportion, perhaps 50 per cent, develop recurrent aneurysms, and this is due partly to the fact that they don't rest long enough after operation. I think if you return these men to duty within three months, your patients, and after all we exist for our patients, will be sorry. I advocate a much longer rest, and remember that men in B.7 category do have to march two miles.

*Major J. Shorclon*

Regarding injuries to the carotid artery, I have had three tears of the carotid artery in the cavernous sinus. In these I have ligated the vessel twice, and both patients survived without neurological signs. In the third patient we did not suspect injury of the carotid artery, and he died on the 12th day from subdural hæmorrhage. A further six patients with hemiplegia had very extensive bruising and injury of the vessels and other structures of the neck. One had a very superficial foreign body which had penetrated the sternum and come out again, but had torn the internal carotid. In five of these six patients hemiplegia was present from the time of the wound, and in one it came on the fourth day after the wound. This patient died after an epileptic fit. Other patients have been seen who had hemiplegia but no tear of the carotid, and three of these patients came to post-mortem.

In these missile cases with torn arteries I excised the injured vessel and they made very good recoveries. I think my experience in this very small number of cases rather bears out what one had thought about carotid ligation, and that is, that the fact of occlusion of the internal or common carotid

depends very much on the general condition of the patient, and his systolic blood pressure, and the C.S.F. condition. If the general condition is low, as it often is in a patient with a severe wound, hemiplegia is likely. Again, if intra-cranial pressure is high, hemiplegia will follow ligation of the carotid artery. I think that it is important before embarking on operation on the carotid to restore blood pressure by suitable transfusion. If the site of the missile does not directly communicate with the carotid, one's incision should be planned so that one can deal with the torn vessel if necessary.

#### *Brigadier Stammers*

It does seem from this discussion that there is need in forward areas for a reconsideration of the problem of wounds in the region of the popliteal artery. I still think that the vast majority will require ligation, for the fear of gas gangrene dictates very largely what the forward surgeon does. There will be a few where the site of the wound of entry indicates that no large muscle mass has been damaged, and it may be right to treat these conservatively under constant observation — there must be no question of evacuating them. We require more experience with vein grafts and vitallium tubes before being able to decide their value. Finally, Major-General Monro has an announcement to make.

#### *Major-General Monro*

At the risk of trying your patience, I am taking you back to 1916 before making the announcement. It seems amazing what progress has been made in surgery. We started the last war without any real

apparatus for blood transfusion, apart from the direct method. It was not until 1916 that I saw blood transfusion given. That was given by members of the Harvard unit. Two American officers came over and produced a Kimpton's tube, a cylindrical thing you may have seen in a museum, to force the blood in. Leading from that, I would like to tell you of an interesting incident which occurred a little later the same year. I happened to be surgeon on duty. A message came in to say that the young son of one of our most famous physicians was on his way in, seriously wounded. The patient duly arrived, completely unconscious. We had no donors, and I was sent round the tents with a hurricane lamp to see if I could get somebody who would give blood. The first man more or less told me to go to 'that place'. The next said he didn't hold with it. Finally I rudely awakened a great big good-natured Yorkshireman. He seemed a good subject, and when I put it to him he said, "I'll give the lad some blood." We put him on a stretcher, wheeled him along to the theatre, and the transfusion was begun. The patient was given 500 to 1000 cc. He completely recovered consciousness and was able to talk. There was a severe wound of the chest. He was nearly out, but the good-natured Yorkshireman provided more blood. Unfortunately the patient had a massive hæmorrhage into the pleural cavity and died. When you think of the amazing strides that have been made in this war you will welcome the announcement I am able to give you now. At long last, and if this passes the last hurdle, the transfusion officers are to be graded as specialist transfusion officers. It is a fitting tribute to a very fine service.





Friday, 16<sup>th</sup> February, 1945

MORNING SESSION

**Subject: SHORT PAPERS**

*Presiding :*

Major-General Stayer, Surgeon

*Mediterranean Theatre of Operations, United States Army*

Brigadier Edwards

Major-General Stayer, whose presence here is a great compliment to us, has kindly consented to take the chair.

Major-General Stayer

It is a great privilege to stand before you and take part in this meeting, and I appreciate this more than words can tell. At this part of the meeting I don't think I should take up any time. The first paper this morning is by Lt.-Col. Rodgers.





# GAS GANGRENE

by

Lt.-Col. H. W. RODGERS, O.B.E., RAMC

Last November, Brigadier Edwards gave me the opportunity of going to AFHQ to look at the A.Fs. I.1241 that had accumulated during the previous year.

Making the 3rd of September, the date of the landings on the Italian Mainland, the starting point, I read carefully through each form, and I have prepared rather a lot of figures for you to look at.

First of all let me give you some gross figures. There were 312 forms, and on the whole they were filled in with great care. The gross mortality was about 43%, and of the 312, 278 appeared to be cases of myositis, and it is to these cases of myositis that I want to confine my remarks.

I think I can be of most service to you by taking the form as it is, and going through it line by line and telling you what you have reported, laying particular emphasis here and there on evidence which seems to be at variance with the classical description of the disease.

TABLE I

	No. of Cases.	Percentage.	Evac. Time
General Hospital	145	52	3.3
C.C.S.	115	42	1.6
Field Ambulance	8	3	1.0
F.D.S.	8	3	1.0

276

Now coming to the top line of the form. Table 1 shows that 52% of these cases were reported from general hospitals, where the diagnosis was first made, and which they have reached on an average of 3.3 days after wounding. One would have expected more from forward units, but it so happens that the conditions of battle and beach-head that most favour the development of gas gangrene also distract the surgeon's attention from the filling in of these and other army forms. Indeed, one negligent surgeon working for a while in the Salerno beach-head left no less than six cases unrecorded, but later, he recorded most of his cases after becoming Officer in Charge of the Surgical Division of 69 (Br) General Hospital. Such negligence among forward surgeons is fortunately rare, but it does indicate that these figures are an under-estimate as far as the forward figures are concerned.

With the figures in paragraphs 2 and 6 we can calculate the incubation period.

TABLE II

Incubation Period

	Recovered	Died	Total
1st Day	30	19	49
2nd Day	33	27	60
3rd Day	31	30	61
4th Day	14	19	33
5th Day	16	6	22
6th Day	4	5	9
7th Day	4	3	7
7th Day +	9	15	24

Table II shows that quite a large number occurred after the third day. There are two stages in the development of gas gangrene of muscle. First, the preparatory stage in which damage of the muscle

is produced, damage enough to allow the second, or the invasive stage, to take place. If the preparatory or muscle destruction stage is accomplished by the missile itself, the disease will come on early, but, the initial damage to muscle and blood supply may not be sufficient, and it may be left to sepsis to produce the required degree of muscle damage which detonates the gas gangrene many days after wounding. I think it would be healthy modesty on our part to regard all those cases occurring after the fourth day as our failures, and please notice that the late general hospital cases are about as lethal as the earlier cases.

In line (i) of paragraph 3 you have usually stated the missile causing the wound and I have nothing of interest to tell you about that.

Diagram I shows the anatomical distribution of the muscle in which the gas gangrene began, 104 leg, 93 thigh, 33 buttock, 12 forearm, 4 upper arm and 17 shoulder. The lower part of the columns shows the mortality rates in percentages. The solid black illustrates those dying from gas gangrene, and the vertically shaded part, those dying of other causes as well, such as severe visceral wounds of the head, chest, or abdomen, as sepsis, and as uræmia (after the infection has been controlled). I shall return to these renal cases.

TABLE III

Degree of Laceration	Number of Cases
Slight	29
Moderate	18
Extensive	44
No Information	9
TOTAL	100

Table III shows the degree of laceration that occurred in a hundred consecutive cases, 29 had slight, 18 moderate and 44 severe lacerations. In 9, the space was left clear. You will note that in 47% the muscles were not severely damaged. The degree of laceration had little effect on the course of the disease.

TABLE IV  
Leg Cases

With Fracture	45
Without Fracture	17
No Information	30
Foot Injury	12

TOTAL 104

Table IV shows that in 104 cases, 45 had a fracture of the long bones.

TABLE V

Number with Injury to Main Vessels		
Number with Injury to Main Vessels	44	15
Number with no Injury to Main Vessels	28	14
No Information	3	3
TOTALS	75	29

Table V shows that in 104 below knee cases, 59 had an injury and 42 had no injury to a major vessel. The mortality rate was not materially different in the two groups.



DIAGRAM I

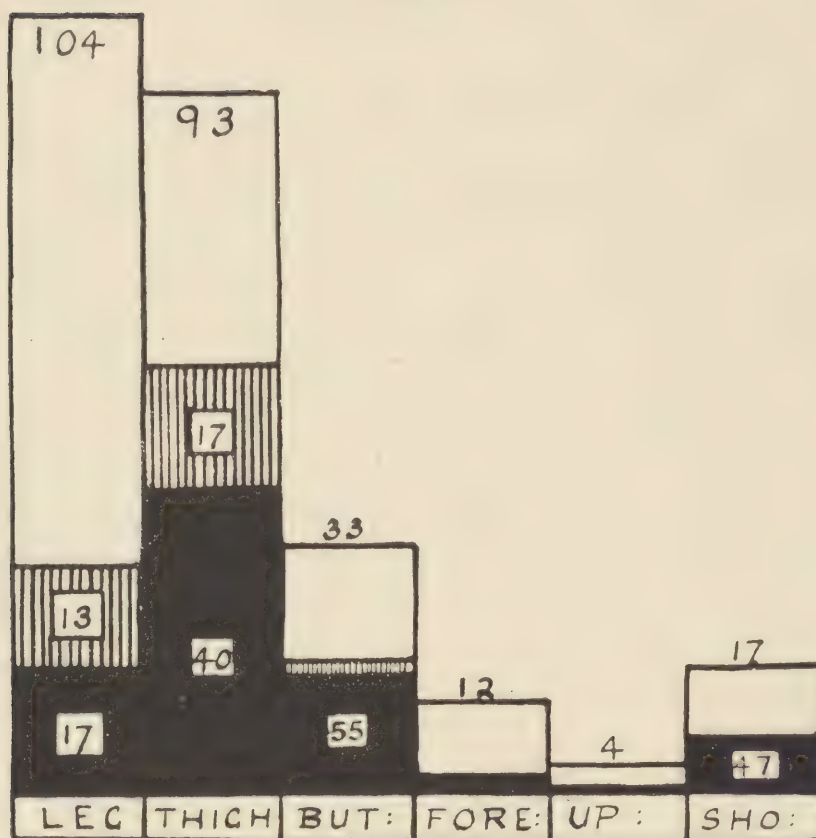


TABLE VI

Number with Prolonged Application of Tourniquet or Tight Plaster - - -	7
Number without Prolonged Application of Tourniquet or Tight Plaster - - -	77
No Information - - - - -	20
<b>TOTAL</b>	<b>104</b>

Table VI shows that in 7 cases the plaster or a tourniquet was blameworthy. Surgical intervention, which is paragraph 4 in the 1940 model but paragraph 5 in the 1941 model, has yielded little that can be expressed statistically. The degree of the excision, which was adequate to prevent gas gangrene, cannot be estimated from the entries that you make here.

TABLE VII

	<i>Leg</i>		<i>Thigh</i>		Totals
	Recovered	Died	Recovered	Died	
Conservative Surgery.	21	4	27	27	79
Amputation. . . . .	55	24	14	27	120
Conservative and Amputation . . . . .	4	4	1	4	13
No Information. . . .	1	1	—	—	2
<b>TOTALS</b>	<b>81</b>	<b>33</b>	<b>42</b>	<b>58</b>	<b>214</b>

Table VII shows how often you were conservative in your surgery and how often you amputated in the leg and thigh cases, but what it does not show is your firm conviction, expressed so often in paragraph 10, that adequate surgery produced a quick and obvious improvement in the patient's condition. The table shows that amputation has a higher mortality than conservative treatment, but it does not give any idea of the severity of the patient's condition at the time of amputation. Now, while amputation is often life-saving, I would like to add without comment that 3 of my own cases, and several that you have reported, have died immediately after a major amputation.

Now, coming to prophylactic treatment. As I am dealing with cases of gas gangrene, I cannot tell you how many cases you have prevented by serum, sulphanilamide or surgery, but all we can do is to see if the giving of serum or sulphanilamide can delay the onset or, more important, reduce the mortality.

TABLE VIII

	0-24 hrs	25-48 hrs	49-72 hrs	73-96 hrs
Adequate Pro Serum (16,500 or more). .	8	17	20	10
Nil . . . . .	16	13	12	7
<b>TOTAL</b>	<b>24</b>	<b>30</b>	<b>32</b>	<b>17</b>

Table VIII shows little significant alteration in the incubation period, except on the first day, where we see that fewer cases had received serum, but this can be accounted for by the fact that a few cases had acquired the disease so soon that the first dose could not be counted as prophylactic.

TABLE IX

Anatomical Region	Adequate Prophylactic Serum Given		No Prophylactic Serum Given	
	Died	Recovered	Died	Recovered
Leg. . . . .	9	24	9	17
Thigh . . . . .	18	10	13	14
TOTALS	27	34	22	31

Table IX shows that no dramatic alteration of mortality rate is produced by prophylactic serum.

TABLE X

Sulphanilamide by mouth	-	-	-	27
Sulphanilamide by mouth and locally	-	-	-	—
Sulphanilamide locally	-	-	-	8
No sulphanilamide	-	-	-	15
No information	-	-	-	50
TOTAL				100

Table X shows that in 50 per cent of cases no information was given about prophylactic sulphanilamide—a pity, because it would have been interesting to know its effect—but all the statisticians will allow these figures to do is to show us how remiss we have been in filling up the form.

The clinical description of the case has been, from the nature of the form, inadequate. I have summarised, in a series selected at random, your description of the pain, pallor, toxæmia, temperature, pulse, smell, mental condition, crepitus and swelling of the part, but I have comments on only three of these that might interest you. (1) All descriptions of the disease emphasise the pain that ushers in the disease, but you have mentioned pain in only 17 per cent of cases. (2) In 60 per cent of the cases you have commented upon the mental condition and in 50 per cent it has been incoherent, disoriented, apathetic, drowsy or comatose, while only in 10 per cent has it been the state of alertness or anxiety so often described. (3) Gas has been felt in 93 per cent of cases and only in 2 per cent have you failed to give information on the point.

TABLE XI

Leg	Penicillin		Penicillin		No Penicillin		Desperate Penicillin		No Penicillin		Desperate Penicillin		Totals
	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	
	1	2	3	4	5	6	7	8	9	10	11	12	
Recovered . . . . .	34	5	19	—	15	—	—	—	—	—	—	—	73
Died { G.G. . . . .	—	—	6	4	4	—	4	—	—	—	—	—	18
{ O.C. . . . .	2	—	7	2	1	—	1	—	—	—	—	—	13
TOTAL	36	5	32	6	20	—	5	—	—	—	—	—	104

TABLE XI (continued)

Thigh & Buttock	Penicillin		Penicillin		No Penicillin		Desperate Penicillin		No Penicillin		Desperate Penicillin		Totals
	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	Serum	Inadequate Serum	
	1	2	3	4	5	6	7	8	9	10	11	12	
Recovered . . . . .	22	8	21	—	1	4	—	—	—	—	—	—	52
Died { G.G. . . . .	2	—	21	5	12	—	10	—	—	—	—	—	54
{ O.C. . . . .	6	1	7	3	—	—	1	—	—	—	—	—	18
TOTAL	30	9	49	8	13	4	11	—	—	—	—	—	124

Table XI shows the influence of penicillin and serum in treatment, and considerable explanation of the chart is needed.

(1) Full penicillin treatment is defined as penicillin given at the rate of 15,000 units, three-hourly for 36 hours or more.

(2) Full serum treatment is a dose of 49,500 units or more repeated at least once.

(3) Inadequate serum is something less than that and it has usually been very much less.

(4) Desperate penicillin is penicillin given in a desperate effort to save the patient's life, but before it could be expected to act, the patient died. I have followed Jeffries and Scott Thompson and others in taking 36 hours as this period, during which you could not expect the penicillin to act fully. This assumption takes some explaining and I will return to it in another chart, but for the moment please accept it as a working basis.

(5) Desperate serum takes a bit more explaining. Now I have assumed that at a certain interval before death from gas gangrene nothing can save the patient. I have further assumed that that interval was six hours, so that any serum given within six hours of death is set so impossible a task that it cannot be blamed for not producing the cure, and so they are excluded from the calculations and shown in a separate column.

(6) "G.G." stands for gas gangrene, and in this column are shown cases dying of gas gangrene.

(7) "O.C." means "other causes"—here such as severe visceral damage which contributed materially to the patient's death, and which it seems wise to leave out of account in assessing the value of this therapy.

(8) Another explanation required is for the absence of any mention of surgery in this chart. If you will allow me to make the big assumption that the quality of the surgery did not vary with any of these forms of treatment, then we will be able to proceed to examine these figures. May I direct your attention especially to the top two rows of figures.

In the leg—you will notice that of 39 cases who received penicillin and survived long enough to have a full course, none died of gas gangrene, whereas of 25 who did not have penicillin, six died in spite of adequate serum. A roughly similar proportion died who had neither penicillin nor serum.



Thus of the 19 cases in column 5 that had neither serum nor penicillin only four died. Notice also the large number that died of other causes.

In the thigh—you will notice the same advertisement for penicillin: 30 survivals and two deaths, whereas without penicillin 50 per cent die. But notice that without either penicillin or serum, 12 die out of 13.

We might conclude from that, that penicillin is of great value and serum of moderate value. But that in the thigh, the omission of serum therapy is dangerous.

Let me emphasise again that I am assuming that these cases had adequate surgery, and I believe the great majority of them did.

There remains this difficult business about the 36-hour period. We could argue that any case surviving 36 hours would live whether he had penicillin or not.

TABLE XII

Interval in hours between diagnosis and death	Without Penicillin			With Penicillin		
	Leg	Thigh	Total	Leg	Thigh	Total
0-12 hours	2	4	6	2	3	5
12-24 hours	—	5	5	2	2	4
24-36 hours	4	3	7	1	1	2
Over 36 hours	4	10	14	—	1	1
TOTALS	10	22	32	5	7	12

In this chart (Table XII), however, you see that of the fatal cases—and all of these are fatal cases—15 died more than 36 hours after diagnosis and that only one had had penicillin. In fact, you may reduce the period to 24 hours and the proportion remains at 3 to 21. However, in the early phases the figures are roughly equal and this forms our base line for the comparison of the striking change seen in the last line.

Good wine needs no bush, and those who have seen the dramatic effects of penicillin in gas gangrene know that penicillin needs no statistics. Indeed, I almost feel like saying the principles of treating gas gangrene are to cut out the diseased muscle and keep the patient alive until penicillin can cure it.

### Bacteriology

The bacteriological results show nothing new or interesting.

In the post-mortem records, two things emerged:

1. The lungs in the great majority of cases showed either gross oedema and congestion or bronchopneumonic changes. This is a change commonly produced by toxins that damage the vascular endothelium. From the therapeutic point of view, I

think it indicated that more attention should be paid to the chest, including the use of oxygen.

2. The kidneys nearly always show some swelling or congestion, and what is rather alarming but of interest is that in 16 cases that died after the clostridial infection was under control, the majority had some evidence of severe renal damage, both ante- and post-mortem. The precise nature of this damage is uncertain, but it appears to be rather like the acute destruction of the convoluted tubules seen in severe shock (as described by Colonel Mallory), also in the crush syndrome, and in certain necrotizing nephroses, such as mercuric chloride poisoning and the toxæmic kidney of concealed accidental hæmorrhage.

Coming now to paragraph 7 (iii), Transfusion:—

The entries here were obviously difficult to assess and I have found it impossible to discover three things which would have been of interest to know.

(1) The relation of massive blood transfusion to progressive hæmo-concentration in the acute phases. (2) The relation of massive saline infusion to the almost invariable pulmonary oedema from which these patients suffer. (3) Some of the cases that occurred later developed their gas gangrene on top of a severe septic æmia that might possibly have been corrected by timely and liberal transfusion.

The neglected septic cases are a good breeding ground for gas gangrene. This is a well-known fact, but lapses in practice have occurred.

### Conclusions

The position as a whole is not too good, and what can we do about it?

As a whole we can hardly hope to improve on the present very efficient evacuation in the forward areas.

Prophylactic serum is widely and conscientiously used, but its value is very doubtful.

The standard of surgery is already high.

Penicillin is of obvious value when the patient survives long enough for it to be used.

Early treatment of septic cases along known lines will improve the position; but the very infrequency of gas gangrene constitutes its greatest danger and requires the greatest vigilance in its prevention.

Finally, gentlemen, if any of you becomes a Freeman of the City of London, you will be given a little red book entitled "Rules for the conduct of life". It was written as long ago as 1738. Part of Rule 3 is applicable to the subject of gas gangrene:

"The man who thinks wisely and discourses judiciously is never to be excused if his practice . . . is not answerable to his thoughts and words."

### DISCUSSION

#### Major Eagles

I have examined a series of 104 cases of gas gangrene from the bacteriological aspect. These have mostly been cases that I have followed clinically as well. The incidence of the clostridia in gas gangrene is much the same as it was in the last war. When one discusses the bacteriology of gas gangrene, it is essential to be sure one discusses the bacteriology of true gas gangrene, and not merely the dirty wound part of it. As is to be expected, almost all

wounds of the dirty type are solidly infected with gas gangrene organisms. Many of these never get beyond that stage if surgery is adequate. The true gas gangrene organism is found in the spreading infection itself. Sometimes there are more than one of the gas gangrene organisms present even in the advanced stage of the infection, but in my series 66 per cent of the cases were of *Welchii* alone, 14 per cent were of septicæ and 9 per cent *œdematens*. A number of the ones that had double infection

showed a culture of *Welchii* in about 20 per cent of the cases, I think that is very much the same as in the last war. It seems there are many strains of *Welchii*. Some do not produce toxin at all, others produce strong toxin. It is worth noting that *Clostridium Welchii* is the most susceptible to penicillin, and *œdematens* the least susceptible, so that the number of deaths in penicillin-treated cases may very well be due to *œdematens* infection, which does throw the picture of penicillin out of focus.

## PRIMARY SKULL CLOSURE WITH ACRYLIC PLATES

by

Major J. SHORESTON, RAMC

In a number of head wounds a skull defect remains the only disability. To the patient it affords evidence of the severity of his injury. It may impose restrictions on his normal activities, and it will reinforce a pre-existing tendency to avoid taking physical risks. These psychological factors not infrequently serve to make a relatively trivial injury into a major disability, particularly if the patient's friends and relatives concur with him in regarding a skull defect as a very serious matter. These and cosmetic considerations make it desirable that skull defects should be covered at an early opportunity; if it can be done at the first operation the patient need never become aware that his skull has been penetrated. In military practice the need for returning patients speedily to duty provided an additional incentive to make us attempt the possibility of primary skull closure.

Even in the pre-penicillin era the results of neurosurgical operations were sufficiently free from sepsis to make the idea of primary skull closure appear possible. The further reduction in infection rate due to penicillin encouraged us to put the idea into practice. With the help of the late Major T. H. H. Wilson, A.D.C., and his technical staff, a method was worked out which has now been used in 48 patients.

The material used was acrylic resin as supplied for dentures by a number of firms. Eight stock sizes of plates are made in the usual manner. Of these, one type is quadrilateral; the sizes used are  $3.5 \times 4$ ,  $4 \times 4$  cms,  $4 \times 5$  cms, and  $4 \times 6$  cms. The other type is round, with diameters of 4, 4.5, and 5 cms. Each plate is slightly curved and should be between 1.5 and 2 mms thick. Perforations are made over the whole surface of the plate; about six should be along the margin.

The operative steps before the insertion of the plate do not vary from the usual routine. Whilst the surgeon is engaged in securing final hæmostasis, a plate of a suitable size is selected from the stock and put into boiling water for five minutes. It is wrapped in gauze, as otherwise it is difficult to find in the water. It is handed to the surgeon as soon as it comes out of the water and whilst it is still hot and slightly malleable. Its edges, and particularly the corners, must overlap the bone defect; they are firmly pressed down and moulded to the con-

tour of the skull. If, after the first attempt, the fit is regarded as unsatisfactory, the plate can be boiled again and its shape modified. In order to prevent the plate from assuming its original shape it should be cooled with saline whilst pressure is still being applied to it. The marginal perforations are next threaded with waxed silk, each strand in its turn threaded onto an eyeless needle and sutured to the fringe of periosteum which surrounds the bone defect. If opposite corners are secured in succession the plate will not be pulled too much on one side. If a self-retaining retractor is used to keep the skin edges apart, its pull should be loosened before the plate is sutured in order to relax the periosteum.

Hæmostasis must be meticulous, for a hæmatoma is here, as elsewhere, a potential cause of sepsis. Troublesome bleeding from under the bone edge can be most easily controlled by taking a stitch through the centre of the exposed dura and two of the central perforations in the plate. When this suture is tied, it not only provides additional anchorage for the plate, but by pulling the dura up against the bone edge, it acts as a hæmostatic suture.

In about half the cases a local sero-sanguinous effusion occurred. In some, the swelling was tense, and the fluid has to be aspirated on several occasions. These wounds did not become infected, and after 10 to 14 days the effusion subsided with or without aspiration.

Sepsis occurred in four patients. The wounds which had originally healed by primary union, began to show signs of inflammation towards the end of the first week. These four wounds broke down, discharged pus, and the plates were taken out. With local penicillin therapy they healed in a matter of days. In all cases, the infection remained superficial. The sepsis rate of 8 per cent in these cases is the same as occurred in comparable cases when no plates were introduced.

TABLE I

Type of Wound	Total Cases	Infected
Missile wound, dura torn	25	1
Missile wound, dura intact	17	3
Compound fracture, dura torn	2	0
Compound fracture, dura intact	4	0
TOTAL	48	4



Thirty-three cases in this series were operated on over six months ago; none of them has since returned to us with wound infection. Twenty-eight of the thirty-three have gone back to duty, mostly in a lower category for three months.

On an average, the introduction of an acrylic plate increases the operation time by ten to fifteen minutes. During battle periods even this brief delay makes it necessary that the method should be used only in entirely suitable cases. The principle of selection which we have adopted is that we repair the skull defect only when the patient shows no neurological disability, or when the disability is so slight that it may be expected to prove transient. In practice, it means that the cases are recruited from those whose dura has remained intact, and from wounds which affect a silent brain area. Of 27 cases in whom the dura was torn, the frontal area was affected 19 times, the occipital lobe five times; in two cases the temporal lobe and in one the parietal area were injured.

TABLE II

Type of Wound	Frontal	Occipital	Temporal	Parietal
Missile wound, Dura torn. . . . .	17	5	2	1
Missile wound, Dura intact. . . . .	8	3	1	5
Compound fracture, Dura torn. . . . .	2	0	0	0
Compound fracture, Dura intact. . . . .	1	1	0	2
<b>TOTAL</b>	<b>28</b> (58%)	<b>9</b> (19%)	<b>3</b> (6%)	<b>8</b> (17%)

There is no lower limit to the size of the bone defect which makes it unnecessary to cover it. In

practice, a proper removal of depressed bone never leaves an opening less than 2 to 3 cms in its longest diameter, and a defect of that size may worry the patient even if it is in the hairy scalp. Bone defects of more than six centimetres in the longest diameter are rare in patients whose neurological state makes them eligible for immediate skull repair, unless the wound chiefly affects the forehead. We have not used the method in the large forehead defects, since an accurate fit is difficult to obtain with preformed plates where the contour of the bone is complicated. Another deterrent has been the increased likelihood of infection when the frontal sinus was opened. A large skin defect which is difficult to close without tension has been another contra-indication.

The advantages of the acrylic plates as we have used them are obvious enough if they are compared with autogenous bone grafts. We have used skull outer table, and chip grafts from the ilium at the first operation, but these procedures prolong the operation so much that they can only be used in selected cases. The healing of the wound and the cosmetic results seemed to be no better when bone grafts were used. Yet, I must confess that I feel that the method I have described is a makeshift one. Although the results have been good so far, I cannot feel happy at the thought of putting foreign material into the body, and if time and opportunity offered I would prefer to put in bone chips. I regard the method as the best under the conditions of war surgery when one has to deal with a large number of cases, and no more.

In conclusion, it may be said that we have found acrylic plates suitable as a cover for medium-sized bone defects at the first operation, particularly if the wound involved the hairy scalp. Only patients who may be expected to return to duty have been so treated. The early sepsis rate was no higher than in wounds into which no acrylic was introduced. The possibility of later complications remains, but it is unlikely that, if they occur, they will cause other than superficial sepsis.

## DEEP INTRAOCULAR INFECTION DUE TO MINES

by

Lt.-Col. RYCROFT, O.B.E., RAMC

It is instructive to look backwards over past campaigns and to note how changing methods of warfare have influenced the ophthalmology of war. Amongst the many problems which the military ophthalmologist of today is called upon to face none is more interesting, nor more difficult, than that of the non-magnetisable intraocular foreign bodies which result from mine explosions.

At the beginning of this war our military conceptions were forced to change from those of static warfare and trenches to those of mobility and mechanisation. The enemy was not slow to realise that in mine warfare he had a potent weapon of defence under these conditions, and he exploited

this weapon to the full in Italy, where natural barriers have also assisted him.

With mines came multiple penetrating wounds of the eyes caused by fine stone particles, and hard upon these there followed gross infection of cornea, anterior chamber, iris, lens and anterior vitreous.

It is a truism that the nature of intraocular foreign bodies often reflects the fortunes of an Army. In retreat they are more commonly magnetisable from shell casings; in resistance, mortar fragments and nickel bullet casings are found, but in advance mines give rise to the majority of them.

At one time 70 per cent of all penetrating wounds of the eyes in a Base Ophthalmic Wing were due to

mines. The mine which has been responsible for most of these eye wounds is the Schu Mine 42, which in principle consists of a container of wood, glass or perspex and which is actuated by an igniter of bakelite or brass. The latest patterns consist almost entirely of non-magnetic material. The common lesion which this anti-personnel weapon produces is the loss of one or both feet of the man who treads on it, with penetrating wounds of the eyes of nearby comrades. There is often no other serious damage beyond splattering of the face and neck with stone particles.

A blind man is as much a casualty as a dead man and far more of a liability to an attacking army.

The local effect of these injuries to the eyes is intense pain and photophobia which lasts for many weeks, along with considerable swelling of the lids (blast oedema). Tiny grit foreign bodies come to lie at all depths of the globe. They infiltrate and penetrate the cornea in several places and produce a resistant purulent infiltration; in the anterior chamber, there is hypopyon; in the iris, there are holes and iritis; in the lens, there is cataract; and in the anterior vitreous, where they finally terminate, deep infection is set up.

The end result is plastic iritis, cataract and secondary glaucoma, producing blindness from shrinkage or loss of the eyes; all this because of tiny particles which elsewhere in the body are of no account.

Having appreciated the magnitude of this menace we set to work to review our methods of coping with it. It would appear that 40 per cent of all mine cases are preventable in that they occur under circumstances where the eyes would have been saved had there been some sort of protection available. Such instances are when clearing known and unknown minefields, booby traps in houses, in rescue work and at demonstrations. Men have been blinded on all these occasions.

In the last war eye vizors attached to the steel helmet had been sponsored notably by Sir Richard Cruise. The objections then made were that rain obscured the gratitudes of the steel mesh work, that when the helmet was blown off so was the vizor, that the field of vision was restricted, and that the men felt strange in them and could not wear them.

In Italy a perspex vizor which is attached to the face like an anti-gas eyeshield with tapes has been devised. This vizor weighs 2½ ozs and is capable of resisting mine blast at close range; it also allows of a full field of vision. Two hundred vizors were sent up to the Armies before Florence for an opinion as to their practicability in actual battle. The reply was that, with modifications, such protection would increase morale and save sight; they recommended their provision. Accordingly the vizors were modified to prevent optical distortion and sun-glint and are now being issued in quantity to selected troops.

There is no intention of a general issue to everyone. These vizors are primarily designed for special troops such as assault, pioneers, sappers and so on, whose job it is to live and work amongst mines.

The next step in dealing with mine injuries of the eyes was to educate general surgeons at field surgical unit level in the preliminary measures to prevent infection. Brigadier Stammers spread the

gospel of the cleaning of the skin of the lids, the cutting of lashes, removing loose foreign bodies, instilling atropine in every eye injury and protecting penetrating wounds adequately.

Close at hand was placed a mobile ophthalmic unit with a skilled ophthalmic surgeon, a trained team and full equipment. Here prolapses were excised, intraocular foreign bodies dealt with, conjunctival flaps sutured in place and, most important of all, penicillin was applied to the wounded eyes.

Thus, eyes were made travel-safe and could be safely despatched by air, road or sea to a base ophthalmic wing for more deliberate treatment. These large base ophthalmic wings offer every modern refinement for the care of wounded eyes.

As a result of experience the treatment at base of deep infection which follows on mine wounds has crystallised as follows:—

(1) Local penicillin is continued either by drops (1,000 units per c.c.), by ointment (2,000 units per gramme, lanette wax), by powder or by subconjunctival injections (1,000 units per minim). Parenteral penicillin has not been found to be of great value.

(2) Chemotherapy consists of full courses of sulphathiazole or sulphadiazine. These drugs are particularly of value where the vascular parts of eye such as the uveal tract are involved and especially when there are concomitant infected skin wounds.

(3) Non-specific protein shock therapy is used to boost sulphonamide treatment. Intra-venous T.A.B. vaccine is employed in doses of 50-70 millions and this remedy is of great value when hypopyon or iritis is present.

(4) Penicillin has come to be regarded by the ophthalmologists in this theatre as a prophylactic rather than a curative measure.

Experiments have shown that in local use penicillin is compatible with all common drugs used in ophthalmology and that for conjunctivitis, seborrhoeic blepharitis and the sterilisation of the conjunctival sac it is supreme. For corneal ulcers it is not quite so valuable unless secondary to conjunctival infection.

\* With the aid of Majors Facey and Cunningham, it was possible to show by experiment that parenteral penicillin did not reach the aqueous or vitreous to any great extent, and it is clear that in deep intraocular infection this route has not produced very beneficial results.

Also, opinions are divided as to its value when injected directly into the chambers of the eye. It is possible that it may check infection, but since the products of such infection remain, blindness still ensues.

Subconjunctival injections offer great promise as they can be brought into use early and this is the route we are now busily pursuing. Penicillin is so readily diffusible that there is little doubt the depths of the globe can be reached by these means.

To conclude I offer this summary as representing the combined experience of C.M.F. ophthalmologists in their efforts to check blindness from infected eyes due to mine wounds:—

(1) Attempts to prevent some of these wounds by the use of anti-mine vizors.



(2) The education of general surgeons at field surgical unit level in the preliminary appreciation and care of eye wounds.

(3) The provision of skilled surgeons and mobile ophthalmic units at forward "bottle neck" casualty clearing stations.

(4) The routine use of local penicillin in every case of penetrating wound of the eye as early as possible.

(5) Rapid air evacuation to a base Ophthalmic wing.

(6) Routine sulpha therapy, protein shock and continued local penicillin along with skilled surgery by men of mature experience.

#### *Major-General Stayer*

Thank you for a very interesting paper. I would like to know if Air Commodore Lyle would like to offer a few remarks.

#### *Air Commodore Lyle*

I would like to congratulate Colonel Rycroft on a most interesting paper. I have not very much to add to it, except to say that in my experience cases of mine injury are extremely difficult to treat, and the results are far from satisfactory. Therefore it would seem that the most important thing is to try to prevent injuries of this sort. I cannot help feeling that this vizio which Colonel Rycroft has introduced will go a long way to preventing many of these injuries if universally used. The main difficulty is to get men to use appliances of this sort when they have so much other equipment to carry about. The final result of these cases of mine injury is, on the whole, I think, not a satisfactory one, but I am sure that penicillin has gone a long way to preventing and combating infection.

I think Colonel Rycroft is to be congratulated on his organisation of the work in this theatre of war, and the most excellent team work that he has with all his specialists. I have been most happy to be associated with him.

## THE TREATMENT OF WOUNDS INVOLVING THE TEMPORAL BONE

*by*

Lt.-Col. W. A. MILL, RAMC

Wounds involving the temporal bone are seen in varying degrees of severity. The size and shape of the missile and its velocity are, of course, of obvious significance. So also is the direction of its passage into, or through, the bone. The temporal bone is very different in structure in its different parts. The squamous portion is thin, and missiles readily penetrate the skull here. The petrous portion of the bone is much thicker, and as the mastoid part of it contains, in most cases, either air cells or diploetic bone, a missile will often pass through or into it without causing much surrounding disturbance or damage. Penetrating wounds of the skull are not often seen in the mastoid region. It may be that in some cases such wounds are immediately fatal from damage to the brain stem, but it is likely that the thickness of the bone and its structure cause the missile to slow up and stop in most cases. I may mention that a missile is more likely to do serious damage if it approaches the head from the side. Damage to the lateral sinus is sometimes seen and rarely to the internal carotid artery. The jugular bulb may be damaged. The facial nerve often suffers and labyrinthine function is often destroyed. C.S.F. otorrhœa is not uncommon, and this is a complication that causes considerable anxiety. A small foreign body may enter the cochlea by way of the external auditory meatus and C.S.F. otorrhœa may result from such a wound.

The following two cases illustrate that the temporal bone may be involved in wounds without any serious result:—

(a) An officer admitted to hospital recently for another wound asked that his ear might be examined. Some months previously he had been near a shell-burst when something had hit him just behind the ear, with the result that he was knocked

down. There was a little blood behind his ear, but he did not bother about it (except that a day or two later his ear was syringed because he felt slightly deaf). No aural symptoms persisted, X-ray examination disclosed a metallic foreign body in the mastoid. There was no reason to remove it, and it was left.

(b) Just a week or two ago an operation was undertaken for stenosis of the external auditory meatus resulting from a through and through gunshot wound sustained six weeks previously, which had passed from the cheek to an exit wound over the mastoid. In the course of the operation it was found that the outer surface of the mastoid had been guttered and loose fragments of bone were found. There was no sign of bone infection.

Such cases of guttering of the temporal bone and through and through wounds, passing from the cheek to the mastoid region, are not uncommon. A number have been seen which have healed without any operation. Some of them, of course, suffer from facial paralysis and complete loss of labyrinthine function. These are usually, but not always seen together. I do not intend to discuss these.

Associated with the damage to the temporal bone and the structures it contains there is, as has already been mentioned, not uncommonly, C.S.F. otorrhœa. The great danger when this is present is, of course, meningitis. As a rule, C.S.F. otorrhœa stops in the course of a few days, or at the most a week or two. A course of sulphadiazine is given to guard as far as possible against the development of meningitis. This is not always successful, as the following case shows:—

A patient reached a base hospital three days after receiving multiple wounds. There was C.S.F. otorrhœa. A small metallic foreign body could be

seen embedded in the inner tympanic wall. Sulphadiazine in large doses was given, and two days later, when his other wounds were being treated under a general anæsthetic, the foreign body was removed by way of the meatus. As it was lifted out, several cc.s of C.S.F. gushed out. Three days later he developed symptoms of meningitis, and in spite of continued treatment with sulphadiazine and penicillin given intra-theccally and later by the cisternal and intra-ventricular routes he died in a week. It is interesting that the C.S.F. at the first lumbar puncture contained staphylococcus aureus and coliform bacilli, while from later specimens cultures grew only coliform bacilli.

A recent case of C.S.F. otorrhœa associated with a fractured skull (the result of an accident) gave rise, in spite of the normal precautions, to severe otitis media, and later mastoiditis with extra-dural abscess formation. Two other cases of gun-shot wound of the mastoid with C.S.F. otorrhœa in whom meningitis had developed were successfully operated on after the meningitis had settled down with chemotherapy.

In conversation, Major Shoreston has told me he thinks that C.S.F. otorrhœa is due in most cases to damage in the internal auditory meatus. This is very likely so, but not invariably the case. The case just referred to regained normal hearing.

### Routes of Infection

I would like to mention the routes by which the mastoid and deeper structures may become infected.

Besides the danger of infection by way of the wound and the fractures leading from it, and through the ruptured tympanic membrane, there is also the possibility of infection by way of the Eustachian tube when the tympanic membrane is intact. A patient treated a few months ago had a linear fracture of the skull, passing from the parietal bone down into the temporal bone and ending in the tegmen tympani. Through the intact drum the middle ear was seen to be full of blood (hæmato-tympanum). In the course of a fortnight this became infected. At operation two weeks later a large extra-dural abscess was found under the fracture of the squamous part of the temporal bone (no doubt an extra-dural hæmatoma had become infected from the middle ear). The mastoid was also infected and a cortical mastoid operation was performed.

In cases of wounds involving the temporal bone, the tympanic membrane is usually ruptured, and most cases reaching a base hospital are found to have otorrhœa due to otitis media. This may suggest that there is widespread infection throughout the mastoid. In the majority of cases this is not so. With simple treatment the otitis media will in most cases settle down.

Before any operation is undertaken X-ray examination is important; beside the usual lateral oblique mastoid views and the mastoid tip picture (postero-anterior oblique view), at times Stenvers' and the Towne's views are useful, especially in locating exactly the position of foreign bodies.

### Treatment of Cases seen Early

Cases, when they reach a base hospital, if there is no obvious infection of the wounds, are explored. Any loose pieces of bone are removed and, of course, the foreign body also. The wound is dusted with ca. penicillin and it is then sutured. A small "penicillin" tube is introduced through the lower

end of the mastoid incision. After sucking out blood and serum 5 cc.s of sodium penicillin solution (500 units per cc.) are introduced by way of the tube twice daily for five days or so. The external auditory meatus, if it is torn, is lightly packed with vaseline gauze upon which ca. penicillin has been blown. This is done in an attempt to prevent stenosis. The majority of cases heal without delay.

When the lateral sinus is found to be ruptured it may be closed by a muscle graft, or failing this, by plugging. A muscle graft has been successfully used to close a torn jugular bulb (Captain Tutton and Major Whittaker).

A trained neuro-surgeon should be asked to take over should a penetrating injury be found.

### Treatment of Infected Cases both Early and Late

What I am now about to say applies to infected cases both early and late. In an infected case there is usually no immediate urgency for operation.

If there is obvious infection of the wound, it has been found by experience that in most cases the cells damaged by the missile are those infected and that the rest of the mastoid cells are not infected. X-ray examination will help to determine in some cases whether all, or only some, of the mastoid cells share the infection. It must be remembered that extravasated blood will cause opacity. However, if all the cells are opaque, it is likely that this indicates infection.

When the wound in the superficial tissues is just over the infected cells, it is likely that fairly good drainage is provided. If there is infection of all the mastoid cells, drainage is certainly inadequate, and the usual signs and symptoms of acute mastoiditis may develop. Pain and tenderness, swelling, a more profuse discharge from the meatus and the wound and a rise in temperature may be seen.

In infected cases the wound should be explored. A decision as to whether or not a mastoid operation, by which I mean a complete removal of all cells, is necessary should be deferred until the wound has been thoroughly examined. It is not uncommon to find a cavity in the bone lined with granulation tissue and containing bony fragments. In such a case the bone and foreign body are removed, and the abscess cavity provided with good drainage. It has been usual to put in a light vaseline pack, and to introduce also one or two penicillin tubes. The wound is left open. Later, if necessary, the wound may be sutured. If it is found that there is no such abscess cavity, then in one or two parts of the wound a little more bone may be removed to explore surrounding cells. If these prove to be infected the complete exenteration of all cells must be done.

There is considerable difficulty in operating on the mastoid bone if, owing to fractures, large portions of it are "springy" and are seen to move with any pressure of the gouge or bone curette. As far as possible the hammer is not used, but the work of removal of bone is done with the gouge driven by the hand only.

Experience has, in most cases, shown that in spite of the infection of the wound, and in spite of the purulent otorrhœa, mastoid infection is confined to cells actually damaged by the missile, and for this reason and because satisfactory results have been obtained, the limited operation briefly described is done wherever possible.



If continued discharge, either from the wound or from the meatus, indicates residual infection, a mastoid operation may be done at a later date. My experience of complications as a result of infection has been limited to that already mentioned, meningitis and extra-dural abscess; no doubt others occur.

To those who see these cases early, I would suggest that they make sure that nothing, other than a piece of sterile cotton-wool, is put in the meatus if the drum is ruptured. If C.S.F. otorrhœa is present, a sterile dressing should be applied to the ear and changed as often as necessary, but nothing should be put in the meatus. Sulphadiazine should be given. If the meatus is seen to be torn, its replacement as far as possible and light plugging with vaseline gauze may prevent stenosis developing.

Cases of facial paralysis with few exceptions have not been treated in this theatre.

I wish to thank Major Whittaker of 66 (Br.) General Hospital (late of 65 (Br.) General Hospital), with whom I have had the pleasure of working, for much of the information from which this short note was made possible. Also I would like to thank the members of Major Shoreston's Neuro-Surgical Unit, both he himself and Captains Tutton and Jepson, for their co-operation and help.

Mastoid wounds in the last war bore, I understand, an evil reputation. This is not the case in this war. I wonder if it was because extensive operations undertaken with the hammer and gouge on the "springy" bone broke down barriers to the spread of infection which had formed. We have learned to do less. No doubt chemotherapy has helped us a lot. I always like to remember Trotter's remark, "Gentlemen, you cannot kill the streptococcus with a knife", and this may well be applied to the hammer and gouge to a large extent.

## THE IMPORTANCE OF THE POST-OPERATIVE BLOOD PRESSURE

by

Lt.-Col. R. T. GRANT, RAMC

I think it is fair to say that up till now too much attention has been paid to the pre-operative and operative stages of a wounded man's illness. There is still a great deal to learn about what happens after operation. Of that, I think we do not know very much. I am quite sure it is just as important to watch the patient closely during the 24 or 48 hours after operation as before, for we can regard the operation as a second injury.

But you may ask first of all, "why should blood pressure be important to follow up after operation?" The answer is that one of the outstanding results of a major wound is some disturbance of the circulation, and these changes are definite and you must recognise them. This disturbance of circulation is just as frequent if not more so after operation as it is in the earlier stages, and surely the blood pressure is the best indication we have of the degree and nature of this upset.

It is important to add that it is not sufficient to take blood pressure by itself. One must take into account other signs and symptoms.

There are, as far as we know, four syndromes with low blood pressure. Two are associated with vaso-constriction, and two with vaso-dilatation. These four syndromes must be recognised. In the post-operative stage only two of these are of importance. One we call cold hypotension, and the other warm hypotension.

### 1. Cold Hypotension

I had better explain clearly what is meant by vaso-constriction and vaso-dilatation. The state of superficial vaso-constriction is shown chiefly by a thin pulse; on putting the finger on it, it is not wide but narrow. The veins are small, and when you try to draw a sample from the vein, the blood won't come, or only very slightly. The extremities are all

cold. Nose, ears and toes are cold, and the face is pale. These are the signs in which you recognise peripheral vaso-constriction. These signs you get with cold hypotension.

### 2. Warm Hypotension

With warm hypotension, on the other hand, you have a wide pulse and warm extremities. Fingers, toes, nose and ears warm. The face is not pale but normal colour, even flushed, so that these two conditions, both with low blood pressure, look vastly different. The patient with cold hypotension looks ill, and the patient with warm hypotension looks well. Because he looks well this syndrome is not often recognised. Cold hypotension is common before operation, and presents the ordinary picture of shock and low blood pressure. If you find this in the stage before operation it is closely associated with a low blood volume, and is an indication for giving plasma. After operation that interpretation is much less certain. All you can say after operation is that this syndrome indicates more likely than not, that blood volume is low. I do not mean to say of course that in every case of cold hypotension you should transfuse at once, because in most cases lowering of blood pressure passes off in two to four hours, but if this has not passed off in three of four hours, you must watch to see what happens and then transfuse. But you may ask how it is likely that these cases which have presumably received transfusion before or during operation should come after operation to have low blood volume? The answer is that measurement of blood volume often shows previous transfusion to have been inadequate. Blood loss is often greater than is thought at operation. A good deal of transfused fluid given before or during operation soon leaves the circulation, but one case given 1200 cc of plasma within an hour had retained only 800 cc, so that blood

loss is more than one thought, and a good deal of the transfusion given runs out of the vessels very soon.

One other point; before operation you can restore circulation without restoring blood volume, and though the patient may look alright blood volume may be 20 or 30 per cent lower than normal. So it happens after operation that patients who show this syndrome often have very considerably reduced blood volume. The explanation in other cases we do not yet know. It is quite clear that this syndrome should not be allowed to persist, because sooner or later danger arises from this poor blood volume.

A word about warm hypotension. This is common before operation and very common after operation. It is often most difficult to detect because the patient does not look ill, has a good colour, and is warm. These cases have low blood volume, lower than normal, but that is not the main picture. The main picture is rather complex. It is favoured by warm surroundings. Warm hypotension is common in warm weather or where the patient is unduly warm in bed. It is found as a result of ether anaesthesia. In these cases where hypotension develops under ether it is usually of mild degree and passes off in an hour or two as the patient recovers from the

anaesthesia. One sees most frequently this picture of low blood pressure with a pulse perhaps of 140 where the man has a large injury, especially one with much muscle damage. As regards treatment of this syndrome, we do not yet know very much, because it may be associated with a lowering of the blood volume, and although on transfusion some restoration may be effected with a slowing of the pulse, the man remains essentially in the state of warm hypotension. It is worth while trying the effect of drugs. With a substance like neo-synephrine blood pressure falls after an hour or two and the patient goes back almost to his previous state. This may last 36 or 48 hours. Then we find blood pressure going up slightly and it is two days more before it returns to its normal state. Cold hypotension should not be allowed to go on, for what we see on the surface is also general throughout the body. Although blood pressure is low, the flow is quite sufficient to maintain life but insufficient for the proper functioning of the various organs. For example, the renal system does not work unless blood pressure is sufficient. This warm hypotension results in reduction of urine flow and this also happens with cold hypotension. Here, once you raise blood pressure, the urine flow starts.

## HAZARDS OF TRANSFUSION

by

Lt.-Col. G. E. W. WOLSTENHOLME, RAMC

In the past year the British Base Transfusion Unit in Italy bled over 52,000 Group 'O' donors. The general hospitals bled at least a further 5,000 donors of all groups.

The Base Transfusion Unit also issued more than 80,000 bottles of plasma and just under 100,000 bottles of glucose-saline; other crystalloid intravenous solutions totalled 22,000. Altogether we can reasonably assume that not less than quarter million pint bottles of solutions were administered during the year. Apart from some 4,500 blood and a few hundred glucose-saline, these figures do not include any for American units.

To the fluids provided by the B.T.U. at least 18,000 3 gm. solutions of sulphadiazine and thiazole were added; also considerable quantities of gas gangrene antisera, penicillin, and pentothal.

That so vast a river of fluids should disappear into the bloodstreams of many thousands of wounded men suggests an unimpeded, uneventful flow from base to patient. But how much was this apparently smooth flowing river contaminated, what turbulence attended its final course, and what silt was carried to the deltas of many kidneys?

Our principal endeavour in intravenous therapy was five-fold; to increase blood volume in acute hæmorrhage and conditions of circulatory collapse; to replace erythrocytes in anæmia secondary to sepsis and chronic hæmorrhage; to provide protein; to combat dehydration; and to administer drugs and sera. In fulfilling these tasks we knowingly ran certain risks; the risks of introducing inorganic

and organic matter, bacteria, parasites and viruses; the risks of mixing bloods incompatible to a major or minor degree, or accumulatively incompatible; and the risks of injecting proteins to which the patient might be abnormally and dangerously sensitive.

These are no small risks and the responsibility in carrying out this work is no light one; it rests principally on those excellent ungraded specialists, the F.T.U. officers, but rests also on every surgeon.

How well has this responsibility been discharged?

It is notoriously difficult to assess the incidence of reactions to transfusion and infusion fluids. In the monthly return rendered by F.T.U.'s and general hospitals reactions are classified under three headings, all concerned with rise in temperature, but in practice reactions of any type attributable, sometimes rather remotely attributable to transfusion are included. In 1944 the reported incidence of reactions varied from 7 reactions with the first 6,500 bottles of blood given at Anzio, to 96 reactions with 109 bottles at a general hospital. At the hospital it was added, as a matter for satisfaction, that only 6 of the 96 reactions had been severe. Forty-nine general hospitals in CMF reported together 1,066 reactions of all types with nearly 14,000 blood—about 7.7%; the incidence was greatest with 2,185 blood in September when it was 11% and least in December with 1,334 blood when it dropped to 3%. F.T.U. officers are more practised with the needle than the pen, but 4 of them reported a total incidence of 6.2% reactions with 3,739 blood.



These Italian figures may be set against Jewesbury's statement in an article in the B.M.J. in May '41, that febrile reactions are to be expected in 20%, and rigors in 5% of transfusions with stored blood.

The causes of reactions have been variously categorised; in these few moments it will perhaps be most profitable to consider them under four headings; chemical, bacterial, hæmolytic and proteolytic.

The simple pyrexial reactions common to all transfusions and infusions are undoubtedly due to lack of care in the cleaning of equipment and in the preparation of solutions. Traces of old blood or plasma in tubing and glass-ware, dead bacteria and the pyrogens they may have produced in stale distilled water used for the solutions account for many reactions which are avoidable. One General Hospital halved its reaction rate between July and August by drawing a fresh supply of rubber tubing. Although avoidable, these reactions crop up overseas largely due to unsatisfactory stills, poor quality salts, shortage of materials for cleaning glass-ware, and the necessity for using synthetic rubber from which chalk and colouring matter are removed with difficulty and in the lining of which blood and plasma easily become ingrained beyond the reach of any pull-through. That care has been exercised is shown by the fact that the reported incidence of reactions in the administration of over 10,000 bottles of glucose-saline was 0.2%.

Infection of glucose-saline is uncommon, but at least one death followed the infusion of a bottle containing a mould. Plasma is almost always sterile on culture but the rather numerous reactions—10.7% in one series of 1,823 dry plasma—suggest that dead bacteria or bacterial toxins may be present from the pre-drying period. Infection of blood was reported to be very common by Major Eagles in Col. Grant's report, but in a more recent survey not yet completed the Canadian Research Team is said to have found 60 successive bottles completely sterile. Undoubtedly at the height of the Gothic Line battle the Base Unit found it too great a task to check-group, sort, cap, top and pack 400-500 blood in the 12 hours of night. Air-leaks on the topping machine led to a contamination rate of 15%, and inadequate refrigeration in these first 12 hours permitted the contamination to become dangerously heavy. Limitation of the quantities and tightening up of technique led to a gratifying fall in the incidence of reactions.

Inspection of topped blood does not give much indication of contamination unless there is marked purpling or darkening of the cellular layer. In topped bottles any staining of the plasma above the red cells before the bottle is disturbed should be regarded with suspicion. Prompt and continuous refrigeration satisfactorily restrains the growth of most chance contaminants. The practice of transporting blood forward beyond adequate refrigeration increases greatly the chance of the danger of the blood out-weighing the possible advantages to the wounded man. In general hospitals the practice of opening the blood refrigerator at frequent intervals to remove penicillin or sisters' fruit jellies may mean that the inside temperature never drops below 12° or 14° C, and similarly increases the danger. Blood storage is necessarily Priority I in the use of the few refrigerators available.

Transmission of disease cannot be completely excluded. Malaria was expected to be a great problem, but reported cases in which transfusion may

have been responsible for transmitting the disease have been very few. In one case, where the blood of a donor who never reported sick was said to be full of parasites and caused a violent reaction, the blood had been stored in a refrigerator for 17 days. Routine examination of blood films has excluded only one bottle. The Russians are said to put 15 gr. quinine in each litre of blood but this is believed only to modify the severity of the transmitted disease. For us in Italy it is essential to have malaria in mind when a pyrexial reaction follows a blood transfusion.

There is an increasing risk of transmitting syphilis. Use of volunteer donors limits the risk; klan tests of the donor's blood are unfortunately not of great value for they may be negative when he is most infective and may be positive when he could give blood with impunity. Storage with adequate refrigeration is a good safeguard, and by the time blood is given in forward areas the risk of introducing viable spirochaetes is not great. Where fresh blood is used volunteer donors should be questioned privately and pointedly, the risks to the patient being explained.

We have noted that hæmolysis should be suspect in the topped bottle. Blood should always be judged by its appearance and not by its age. In general hospitals the indications for transfusion will generally exclude the use of blood more than a week old. In the restoration of blood volume blood of good appearance 2-3 weeks old can be given in moderation safely and with good effect. Some of the pyrexial reactions may be due to quick breakdown of cells of older blood in the patient, rather similar to the fever in malaria as the red cells are destroyed.

Transfusion of grossly incompatible blood should never occur. Although there have been reports of incompatible transfusions we do not know of any bottle sent out as Group 'O' proving to be of some other group. When dry grouping serum or wet grouping serum which has not been kept frozen are used, controls should never be neglected. Cross-matching is essential. When the groups are correct, incompatibility is still a possibility. Much darkness still reigns in regard to a number of hæmolytic reactions, despite the enlightenment in recent years about the danger of repeated transfusions of Rh<sup>+</sup> blood to Rh<sup>-</sup> patients. That kidneys surviving massive muscle wounds, crush injuries, or sulpho-nyamide therapy should be knocked out by unsuitable blood intended to be life-saving is a tragedy which we must do our utmost to avoid. No blood should be given without cross-matching if time permits—and if time does not permit the danger to life must be presumed to be already greater than any likely to arise from the blood.

This is not an opportunity to discuss quantity and rate of administration, but we must remember that rigors may occur with too rapid introduction of fluid and that præcordial pain, respiratory distress, and a sense of fullness in the head are symptoms common to the transfusion of too much blood and of incompatible blood, and only an examination of the urine may enable us to distinguish between them. The importance of prescribing the type of fluid, the quantity and the rate for each patient is however surely fully appreciated in this Theatre.

Anaphylactic and allergic reactions to blood and plasma are not uncommon, occurring apparently with more frequency among Indians, presumably



due to proteins being present to which they are not accustomed. Mostly the reactions are no worse than mild urticaria, but very severe reactions of an anaphylactic nature have been reported with some dried plasma, associated in recent cases with difficulty in reconstitution. This is under investigation. The possibility of this type of reaction must be borne in mind and means to treat it kept at hand.

Enough has been said of chemical, bacterial, hæmolytic and proteolytic hazards to emphasize the great need for unceasing care in transfusion and infusion. Ease of supply and ease of administration must not lead to easy minds. Transfusions and infusions were literally an every minute procedure

throughout 1944 in C.M.F., but the practice must not become too familiar. We need to know much more, which accurate observation and recording may reveal.

The hazards can be avoided only by attention to the points I mention in conclusion. Only whole-time trained orderlies should be employed in the preparation of transfusion equipment. All fluids must be carefully scrutinised before use. Cross-matching cannot be neglected. Accurate, continuous refrigeration of blood is essential.

Reactions are a disgrace to our technique or our knowledge—they must be a stimulus to the improvement of them both.

## THE USE OF CONCENTRATED PLASMA IN THE TREATMENT OF PULMONARY OEDEMA DUE TO TRAUMA

by

Major G. CLELAND, RAMC

When a wounded soldier has developed pulmonary œdema due to blast or certain other forms of trauma, the prognosis is extremely grave. The presence of the condition prior to operation may render the risks of anæsthesia too great to allow operation on coexisting wounds, and thus render the prognosis still graver. But the prognosis is not hopeless, as it is when the pulmonary œdema is in the nature of a terminal event in cases dying from irrecoverable circulatory collapse resultant upon wounding. The results of the method I propose to describe have appeared so striking that I feel the method should be brought to general notice so that its life saving possibilities may be explored more widely.

In seeking a method of controlling this condition, I have brought into use intravenous concentrated plasma as an addition to the more usual therapeutic measures. In my experience, suitable cases are not common, and I have seen fit to use this measure in only 4 cases out of 750 recent battle casualties. These cases, I shall describe. One other surgeon (Capt Denham, N.Z.A.M.C.), to whom I introduced the method, is finding it of value, not only in the treatment of established pulmonary œdema due to blast injuries, but in preventing the development of pulmonary œdema in cases in which blast injury of the lung has been diagnosed.

I must define at this stage the condition which I am calling "pulmonary œdema". It is characterised by the presence of severe respiratory distress and marked cyanosis. Large quantities of frothy mucous are thrown up into the trachea, and well up through the larynx. Varying with the degree of consciousness present, attempts are made by the patient to cough up the frothy mucus. Auscultation of the chest shows the presence throughout of widespread coarse crepitations which sound very close to the stethoscope, rather in the same manner that the whispered voice sounds close to the stethoscope in whispering pectoriloquy. It will be seen that, in this condition, the ultimate danger to life lies in the drowning effect produced by the vast

quantities of mucus in the alveoli and the bronchial tree.

### *Basis for the use of Concentrated Plasma*

I have observed on many occasions that concentrated plasma administered intravenously produces a reduction of œdema in second degree burns, apparently by its direct action in raising the osmotic pressure in the capillaries. It is argued that, if this is possible in œdema due to trauma in other regions, it should be possible in pulmonary œdema due to trauma, though not in that condition produced by circulatory failure when the latter is a terminal event or due to over-transfusion.

It is further argued that by withholding other fluids, the reduction of œdema could be maintained over a period long enough to allow adequate local and general oxygenation to occur with a resultant return to a nearly normal state of the lung capillaries. This would prevent any tendency for the condition to recur. In cases where the pulmonary œdema had not occurred but could be anticipated, the raised osmotic pressure would tend to prevent the occurrence of the œdema.

The truth of this thesis, I am unable to prove; but it certainly appears to agree with the results obtained clinically.

### **Method of treatment**

Many of the recognised methods of treatment for pulmonary œdema of traumatic origin are included, for it must be emphasised that intravenous concentrated plasma is an addition to them, not a replacement of them.

1. Atropine gr 1/50 is administered intravenously to diminish bronchial secretion to a minimum as early as possible. It is considered that the atropine can have no direct bearing upon the actual pulmonary condition.

2. In order that maximum oxygenation may occur, as much of the fluid in the bronchial tree as possible



must be removed. If the condition has only recently developed and consciousness has not been lost, the patient is encouraged to cough up as much of the mucus as possible. More commonly, however, the patient is either completely unconscious or in semi-coma. If this is the case, the patient is laid supine and the foot of the bed raised to encourage the mucus to flow towards the larynx. A tube is passed under direct vision into the trachea and the mucus is sucked out. The injection of coramine 3-5 ccs. intravenously at this stage will often produce a temporary return of the cough reflex. This will bring still more of the mucus into the scope of the suction tube.

3. Oxygen administration is commenced and given continuously by a method which ensures the maximum concentration of that gas in the nasopharynx. The B.L.B. mask proves efficient for this.

4. The above measures are instituted as rapidly as possible and then the administration of concentrated plasma intravenously is commenced. Originally double strength plasma was used (the dried equivalent of 800 ccs. of human plasma dissolved in 400 ccs. of sterile water). Latterly triple strength plasma has been used. (The dried equivalent of 1200 ccs. of human plasma dissolved in 400 ccs. of sterile water.) The plasma is administered by the standard Army infusion apparatus at a rate of about 80 drops to the minute and little difficulty is experienced in maintaining the flow. 400 ccs are usually adequate but occasionally up to 800 ccs is required.

5. Other fluid intake should be limited in order to obtain the maximum benefit from the increased protein concentration in the circulating blood.

### Case Notes

#### Case 1. Private M.

The injuries involved are described in the operation notes. One feels that the nature of the injuries caused by blast from a mine justified the diagnosis of blast injury of the lungs as the cause of the pulmonary oedema which followed operation.

*Operation under continuous pentothal anaesthesia.*

The operation took place ten hours after wounding.

1. Partial amputation of right foot, compound fractures of middle and lower thirds of the right tibia with gross laceration of muscle and a laceration involving the knee joint. A disarticulation through the knee joint was performed.

2. Deep lacerations with gross muscle damage and much earth in wounds behind the left thigh, knee and calf. Gas was found in the inter-muscular planes and early anaerobic infection of muscle was present. Very wide excision, removing all doubtful muscle as well as that obviously infected was carried out. Excision was not ceased until healthy, bleeding, contractile muscle was reached. Tobruk-Thomas splinting was applied.

3. Penetrating wounds of the left buttock were excised and a perforating wound of the right hand with multiple tendon division was cleansed.

During the operation, a state of profound circulatory collapse occurred due to the collapse of compensation. Response to blood transfusion was immediate and after 3½ pints had been administered the blood pressure had risen to 110/80 and the general condition of the patient was regarded as satisfactory.

Within half an hour of returning to the ward, pulmonary oedema occurred, as characterised by severe cyanosis, widespread coarse crepitations in the chest and a bronchial tree filled with pink frothy mucus. Treatment with atropine gr 1/50 and coramine 5 ccs intravenously, tracheal suction and continuous oxygen was commenced. Thrice concentrated plasma was administered intravenously, 400 ccs being given at about 80 drops per minute. Response to the combined measures was immediate and within half to three-quarters of an hour signs of moisture in the chest had diminished to something very slight. There was no tendency for the oedema to recur, a fact which was attributed to the plasma, while the initial improvement was attributed to the vigorous other measures employed.

This case had an extremely stormy convalescence as he was extremely toxic due to his gas gangrene (proved to be due to Cl. Welchii) but he was evacuated ultimately to the base in extremely satisfactory condition.

#### CASE 2. Capt. S.

The injuries in this case were caused by the explosion of a mine under the jeep in which the patient was riding. The force of the explosion was such that the jeep disintegrated and large parts of it were never found.

On admission, the patient was cold, clammy and pulseless. The blood pressure was 50/?, the patient was unconscious and appeared moribund. A hopeless prognosis was given to his friends who came in with him.

The injuries were:—

1. Bilateral blast injury of the lungs, diagnosed on the history, the presence of cyanosis, some respiratory embarrassment and widespread coarse crepitations throughout both lungs.

2. A very large laceration of the sagittal line of the scalp without an obvious fracture of the skull which suggested that his head had met with a violence sufficient to produce the loss of consciousness.

3. A small laceration of the left parietal region of the scalp.

4. A deep laceration under the greater occipital protuberance.

5. A traumatic amputation of the right forearm with shattering of the elbow joint and a fracture of the lower end of the humerus with great coincident muscle damage.

6. Two penetrating wounds of the right shoulder region.

Simple fracture of the left medial malleolus with much bruising and great displacement of the fragment.

8. Severe contusion of the right ankle.

The blast injuries of the lung were regarded as being of the greatest immediate seriousness. It was felt that there was almost no hope that the patient would become fit to stand operation. Blood transfusion was commenced slowly, on account of the chest condition. After two pints of blood had been administered, there had been no evidence of any response. Pulmonary oedema then manifested itself when pink frothy sputum began to well up from the trachea. The depth of unconsciousness was such that the cough reflex was absent.



Treatment was commenced with atropine gr 1/50 intravenously, tracheal suction, continuous oxygen. Coramine 5 ccs was given intravenously while the tracheal suction was being carried out and a temporary but helpful return of the cough reflex was obtained. Triple concentrated plasma (400 ccs in all) was administered intravenously at a rate of 80 drops per minute. In half an hour the colour had improved most markedly and the pulmonary oedema was disappearing. The cold clamminess of the body had disappeared and had been replaced by general warmth and superficial vaso-dilatation. The blood pressure was rising steadily but slowly. Three hours after commencing the treatment for the pulmonary oedema, the blood pressure had reached 110/80 and there was no tendency for the pulmonary oedema to recur. Semi-coma still persisted.

It was now judged to be the suitable moment for operation and it was observed that this was 8 hours after admission to the advanced surgical centre and at least 12 hours after wounding. Operation was carried out under very light pentothal anaesthesia and consisted of rapid re-amputation of the arm through the level of the fractured humerus, excision of all other wounds and single layer suture of the scalp, over sulphanilamide powder, to give maximum speed in closure. The fractured ankle was manipulated and a padded plaster applied.

The condition of the patient did not deteriorate during the operation but in the next couple of hours after operation the axillary temperature rose to nearly 105°F, commencing to fall thereafter on the application of cooling measures. This hyperpyrexia could have been the result of a reaction to the plasma or due to some measure of injury in the region of the heat regulating centre, but whichever was the case, it did not recur.

No more need be recorded of the progress save to reiterate that there was no tendency for recurrence of the pulmonary oedema and information received four months later showed that the patient was alive and physically well, though he was still recovering from marked mental abnormalities as a result of his head injuries. I have never seen a case in which recovery was more unexpected or dramatic.

#### CASE 3 L/Cpl W.

On admission this patient was extremely ill due to a sucking wound of the right mid axillary line of the chest, caused by a machine gun bullet, and other injuries. The operation notes describe the injuries.

*Operation under C2E3 followed by ether.*

An obvious sucking hæmo-pneumothorax was present in the right mid-axillary line. The abdomen showed no definite signs of penetration.

1. The chest wound was laid open and a fracture of the sixth rib was found. The soft tissues were excised and enough of the fractured rib removed to permit inspection of the pleural cavity. A large hæmatoma of the lower lobe of the lung was seen and there was no visible rent in the diaphragm. The wound was closed in layers.

2. A perforating wound of the right elbow, related to the chest wound shattering the lower end of the humerus and the elbow joint was excised and immobilised in a padded plaster.

3. A perforating wound of the buttock required no operation. At the end of operation, hæmoptysis was observed.

Following return to the ward, the condition of the patient was extremely grave and oxygen was administered continuously. During the next three or four hours, there was a gradual recovery and consciousness was regained for a short period. About six hours after operation, the patient gradually lost consciousness, appeared to be moribund and large quantities of frothy mucus welled up into the trachea. Treatment was instituted along the lines already described in the previous cases with the exception that double concentrated plasma was used. The immediate response was dramatic, due to the clearing of the airway to oxygen and over the next half hour the moist signs in the chest were diminishing. This drying effect continued and there was no tendency for the oedema to recur. Consciousness was regained within half an hour. Five days later he was fit for evacuation, there having been no further evidence of pulmonary oedema. Six weeks later he was transferred from the chest unit to which he was evacuated to an orthopaedic centre for treatment of the arm injury, his chest wounds being healed.

#### CASE 4. Lt. T.

This officer was admitted with widespread burns due to a petrol explosion. His general condition was good but standard strength plasma was administered as the amount of fluid loss from the burns which was occurring and likely to continue to occur, was great. The following operation note speaks for itself.

*Operation under continuous pentothal anaesthesia.*

1. Mixed second and third degree burns of face and ears including the lips and the inside of the mouth.

2. Mixed second and third degree burns of both hands with gloving of the hands.

3. Second degree burns of both knees (the patient was in shorts at the time of burning).

All burns were cleansed and dressed with sulphanilamide powder and vaseline gauze and the hands immobilised in the position of function with plaster.

During anaesthesia, vast quantities of mucus welled up into the trachea and the patient became very cyanotic despite the administration of oxygen. A diagnosis of pulmonary oedema was made. The administration of the anaesthetic was ceased, atropine gr 1/50 was given intravenously and the trachea was sucked out under direct vision. During the latter procedure, burning of the larynx was observed by the anaesthetist. As the effects of the pentothal wore off, the cough reflex returned and further quantities of mucus came within the scope of the suction tube. At the same time twice concentrated plasma was substituted for normal plasma until 400 ccs had been given. This was followed by a slow normal plasma drip. Twenty minutes later, on leaving the theatre, the patient's colour was good and moist sounds in his chest, previously abundant, were reduced to a remarkable degree.

Once more there was no tendency for the pulmonary oedema to recur and 30 hours later the patient was in a fit condition for evacuation. In this case it was considered that the pulmonary oedema was the result of burns of the respiratory tract.



(Major Cleland then described three more cases treated by Major D. E. Stephens, SAMC, in all of which the pulmonary oedema was successfully controlled by this method.)

It appears clear that the initial improvement, occurring in the cases of pulmonary oedema described above can be attributed to the standard measures applied. The outstanding advantage which appears to result from the use of concentrated plasma is the tendency for progressive improvement and the remarkable absence of any tendency for the condition to recur. No case which is described above has required more than one clearing of the trachea by suction.

#### *Dangers from the use of concentrated plasma*

Reactions of varying degrees of intensity may occur, but these do not differ from the reactions which may occur when normal plasma is used to replace plasma loss. They only appear to be really dangerous when a serious hyperpyrexia occurs. By careful observation this may be anticipated and the infusion ceased. If, on the other hand, it appears that death is a certainty from the pulmonary oedema, unless administration of the plasma is continued, a fresh amount of plasma may be prepared and given through a fresh giving set and the pyrexia controlled by the usual artificial means.

I have no experience of treating cases of pulmonary oedema in blast lung where no other injuries coexist and where there has been no blood loss. But I feel in such cases, there might be danger from over-loading an embarrassed pulmonary circulation by raising the blood volume above normal. I therefore suggest that in such cases a preliminary venesection might be required in order to "make room" for the plasma that is to be administered. This may be an important danger.

#### *Contra-indication to the use of concentrated plasma*

When pulmonary oedema occurs as the result of over transfusion (an occurrence which I have only once observed in the field, but which at least one of my colleagues has observed a number of times) the treatment required is venesection. Administration of

any fluid to the already overburdened circulation, will cause further deterioration in the condition and therefore concentrated plasma is contra-indicated unless the blood volume is reduced adequately before the plasma is given.

Further applications of the use of concentrated plasma in pulmonary oedema.

1. It seems highly probable that concentrated plasma might prove valuable in pulmonary oedema resulting from the inhalation of lung irritant gases, whether occurring under civilian manufacturing conditions or as the result of chemical warfare.

2. The miner who is burnt as the result of an underground explosion frequently suffers from burns of the respiratory tract. Such a case would probably respond to concentrated plasma in the same manner as the case of burns quoted above.

#### **Summary**

1. Intravenous concentrated plasma is described as a valuable addition to the recognised methods in the treatment of pulmonary oedema due to blast injury and other injuries of warfare.

2. Six cases are described in which pulmonary oedema was successfully controlled by concentrated plasma. One case is described in which pulmonary oedema was possibly averted in blast injury of the lungs.

3. Emphasis is laid on the absence of any tendency for recurrence of the pulmonary oedema in the types of cases described after treatment with intravenous concentrated plasma.

4. Dangers and contra-indication to the method are mentioned.

5. Possible further applications of the method are mentioned.

(NOTE.—I must express my gratefulness to Major R. W. Cope, RAMC, who introduced me to the standard methods of treating pulmonary oedema and who was responsible for this part of the care of two of the patients I have described.

The absence of any references is regretted, as I am at present in the field with a field surgical unit.)

## FOOT STRAIN

by

Lt.-Col. A. S. WESSON, RAMC

After having witnessed the brilliant cortège of speakers and papers this week I feel as must the driver of the dung cart at the end of the Lord Mayor's show.

Nevertheless, though my subject may be dull, its importance, owing to the present man-power situation, will, I trust, justify my occupying just 15 minutes of your valuable time. Like the poor, our feet are always with us, but now in the sixth year of war the foot problem has again reared its ugly head.

I have it on authority that we are losing a number of infantrymen which we can ill afford to spare, on account of minor defects of locomotion. One of the

reasons of this present loss is the fact that infantry reinforcements are no longer men trained fully in U.K. but men from other arms of the service who have been converted into infantry in this theatre, and in the words of the infantry officer "they are damned good chaps but from the waist downwards they are bl. lousy.

I propose first to discuss some of the reasons for locomotor failure:—

(1) Pathological congenital or acquired deformities.

You may well ask "What are these men doing in infantry," but the fact remains that there they are.

After the first year of war, the orthopaedic consultant rightly laid down a ruling that operations on the soldier's foot were taboo, for they more frequently aggravated than relieved his symptoms. I can assure you too that remedial measures have rarely any permanent 100% value and that the only possible remedy is to re-shod and re-employ him at the base, for as an infantryman "he's had it."

(2) Poor muscle tone in the whole locomotor apparatus from the waist downwards. (I say "waist downwards" advisedly, for if those of you who do not know the effect on the feet of contracting the glutei—try it afterwards.)

The reasons for this diminution in muscle tone are:—

- (a) Insufficient use—sedentary occupations. It must be remembered that many soldiers have spent 4 or 5 years employed in occupations involving little or no marching, and it is these who run the risk of locomotor failure during or after their infantry training.
- (b) Incorrect use from habit or post-traumatic states. Incorrect postural habits acquired during adolescence may lead to muscle imbalance in the lower limb with resulting potential weakness. Again, similar imbalance may result from past injuries which have not received adequate rehabilitation.
- (c) Part of a general lowering of muscle tone, the result of hospitalisation from ANY cause.

Now here I must digress for a moment. Those of you who visited the Convalescent Depot on Wednesday heard Colonel Briggs say that all infantrymen before being discharged A.1 must pass two tests—an obstacle course for agility and a 5-mile route march in 1 hour for endurance. May I put in an earnest plea to my audience to consider before they discharge a man direct from hospital to Infantry Reinforcement Training Depot "Is this man really fit for front line duty?" for it is just possible that a man may stay only 48 hours in the I.R.T.D. before proceeding northwards. Please remember that a Convalescent Depot is there to re-fit the man for duty.

(3) The third cause of breakdown is unaccustomed over-loading of the locomotor apparatus.

A commanding officer of an infantry battalion in the line, recently said to me: "The soldier is not expected to march very long distances, nor shorter distances at high speed. What in fact does happen is that he may have to march 10—12 miles at night, in single file, with one foot in the ditch and one foot in the road, avoiding the constant procession of 3 tonners that are sweeping past him. In addition to his normal equipment he has to carry his share of the platoon's weapons and ammunition, 24 hour's rations, a greatcoat and/or blanket and probably pick and shovel."

Is it any wonder, gentlemen, that breakdowns occur?

(4) I fear in a few cases the failure is due to lack of guts. Those, gentlemen, are the reasons. What are the remedies? First, the R.M.O. is most important. A good R.M.O. who nurses his men's feet will save many a potential lame duck—but if the man repeatedly falls out, his only course is to send him to the nearest surgical specialist.

And what can he do?

He knows, and I couldn't agree with him more, that hospitalisation and physiotherapy for such cases result in no permanent benefit and in most cases he must recommend a Medical Board and a lowering of the man's medical category.

I know from my experience of a physical development centre in U.K. that it is possible to save a high proportion of these cases of foot disability without fixed deformities by correct reconditioning. It has therefore been decided to establish a foot training centre in this theatre for 8th and 5th Army Troops. Men with locomotor defects will be recommended by R.M.Os., and selection for suitability will be done by surgical, and when possible, orthopaedic specialists. The centre will be under the supervision of one of my grading specialists, Capt. Brocks. The course will be 6—8 weeks' duration and the programme divided into four fortnightly grades.

The underlying principles upon which the training is based are as follows:—

- (a) Restoration of muscle tone.
- (b) Re-education of normal muscle balance.
- (c) Progressive general and foot hardening.

The programme will include Remedial P.T., General P.T., Recreation, Road-work and in the later stages, cross-country work and hill climbing.

We should welcome any interested surgeon, and Capt. Brocks will only be too pleased to take you round the later stages—I regret I shall not be there!

The men will be reviewed each fortnight and a decision made as to their progress. Obvious failures will be boarded down and sent to the Reallocation Centre. All those who make the grade will be considered A.1 and will be returned to their units direct and not through I.R.T.D.

I realised, however, that this measure, even if successful, is not getting at the real root of the trouble for it must be in the initial training of the converttee that special care is needed. I visited the I.R.T.D. last week and formed the impression that 70% of men would go through normal training and be fit, 15% should never have been sent for infantry training and need immediate recategorisation, and 15% are doubtful cases who would probably break down sooner or later.

In order to save this 15% I have proposed to institute a Special Training Centre on the lines of the P.D.Cs. at home under the supervision of a specialist in physical medicine, such Centre to be formed at the I.R.T.D. itself. By this means it is hoped to prevent the subsequent breakdown and loss to the war effort of that factor of incalculable value—the poor bloody infantry.

In conclusion, gentlemen, I hope I have not disappointed you by depriving you of the spectacle of my flounderings in the quicksands of foot pathology, but by confining my remarks to the wider conception of foot function, its failure and the reasons for it, I have found, I hope, a remedy.

*Surgeon Captain Nicholson, RN.*

I will not keep you for a moment. I just want to tell you how very grateful we are in the Navy for the opportunity of coming here this week and to the previous conference held the week before last. My colleagues and I have gained tremendously from the



advantage of hearing the speakers throughout the week. My own silence I may tell you, is due more to timidity in the face of this outstanding experience and talent than to the term which I believe is usually associated with the service to which I belong. We have heard in references to the papers this week the words "high standard." This is not a high standard; this is THE standard, the standard on which we shall base our future teaching and the standard on which future text books will be written. We are having a preview of the future which is extremely valuable. One other thing. I would like to

thank the British and American Army Services, physicians, surgeons and nursing staffs for the great care they have given to our Naval patients. In the course of the campaign we have had many thousands of them admitted to Army hospitals, British and American, and it has been my great pleasure to see the way they have been looked after. I have been a patient myself. I am glad to say I was not a surgical patient! I should like to thank you again for allowing us to come, and also to thank the organisers for giving us such a successful and most memorable week.

Friday, 16<sup>th</sup> February, 1945

AFTERNOON SESSION

**Subject:**  
**Bacterial Flora of War Wounds  
and Penicillin Therapy**

*Presiding :*

Major-General Philip Mitchiner, Consulting Surgeon

*M.E.F.*

Major-General Mitchiner

I consider myself extremely fortunate in being present here, and I thank you all for having both asked me to come and for being so kind to me since I arrived. I will now ask Major Hamilton of the Royal Canadian Army Medical Corps to give his paper.





# BACTERIAL FLORA OF WAR WOUNDS AND PENICILLIN THERAPY

by

Major J. HAMILTON, RCAMC

During the past ten months the wound infection team of the Research Laboratory has been investigating, first, the bacterial flora of wounds at forward surgical centres, lines of communications and base hospitals, and secondly, the effect of intramuscular penicillin therapy, administered in the forward area, on these wounds. To date, approximately 1,000 wounds have been examined, at various stages from a few hours to several weeks after wounding. As it was found impossible to follow individual cases from forward area to base, the results given below are based on different groups of patients studied at various stages of evacuation.

## CLASSIFICATION OF BACTERIAL FLORA

The various organisms recovered from these wounds have been divided into three groups.

1. *True pathogens*.—These are the organisms which have the power to invade and destroy living tissue:—

Staphylococcus pyogenes (coagulase positive).  
Beta hæmolytic streptococcus.  
Anærobic streptococcus.  
Certain clostridia.

2. *Local pathogens*.—These include chiefly gram negative bacilli, and some other proteolytic organisms:—

Ps. pyocyaneus.  
B. proteus.  
E. coli.  
Coliforms.  
Certain clostridia.

3. *Saprophytes*.—These organisms have a transient existence in wounds and are without significance:—

Aerobic spore bearing bacilli (b. subtilis group).  
Diphtheroids.  
Non-hæmolytic streptococcus.  
Streptococcus viridans.  
Non-pathogenic staphylococcus.  
Micrococcus.  
Certain gram negative bacilli, aerobacter and achromobacter.

Not included in the above groups are cl. tetanus and c. diphtheriæ, which are intermediate between the true and local pathogens listed above. Cl. tetanus has only been encountered about 3 times, and c. diphtheriæ not at all, in the groups of cases included in this series.

## BACTERIAL FLORA AT FORWARD SURGICAL CENTRES

This has varied with the season and with the nature and location of the wounds. Cultures were taken on removal of the field dressing at time of primary surgery.

### 1. Spring and Summer, 1944—(97 cases).

Staphylococcus pyogenes -	-	-	20%
Beta hæmolytic streptococcus -	-	-	3%
Clostridia -	-	-	50%

### 2. Winter, 1944—(234 cases).

Staphylococcus pyogenes -	-	-	13%
Beta hæmolytic streptococcus -	-	-	13%
Clostridia -	-	-	30%

The higher incidence of clostridia in the first group is partly explicable in that a large percentage of these cases were priority I casualties, with extensive wounds. In the cases examined during the winter months, however, the majority were priority III casualties. The increased incidence of beta hæmolytic streptococcus in the winter is to be expected, with the prevalence of upper respiratory infection.

## BACTERIAL FLORA AT L. OF C. AND BASE HOSPITALS

An attempt was made to culture the wounds on first removal, at base or L. of C. hospital, of the dressing or cast applied at time of primary surgery. This was accomplished in a majority of cases.

### 1. Spring and summer, 1944—(87 cases).

Staphylococcus pyogenes -	-	-	40%
Beta hæmolytic streptococcus -	-	-	12%
Clostridia -	-	-	4%

### 2. Early autumn, 1944—(387 cases).

Staphylococcus pyogenes -	-	-	40%
Beta hæmolytic streptococcus -	-	-	7%
Clostridia -	-	-	13%

The striking feature at this level was the high incidence of staphylococcus pyogenes, which was recovered in a moderate percentage of cases from clinically clean wounds.

Although no adequate series is available for the winter months, a marked increase in the incidence of beta hæmolytic streptococcus has been found during December and January.

## EFFECT OF PENICILLIN THERAPY ON BACTERIAL FLORA

Since August, 1944, a large percentage of Canadian battle casualties have been given intramuscular penicillin therapy in the forward area, following primary surgery. The average course administered was 550,000 units over a period of 4½ days, given 3-hourly, 15,000 units per injection.

Bacteriological examination of these penicillin-treated cases on arrival at base hospital showed that the bacterial flora was of the same type, with the same incidence of pathogens, as in cases not treated with penicillin.

## SENSITIVITY OF PATHOGENS TO PENICILLIN

Of the true pathogens listed above, beta hæmolytic streptococcus has always been found to be sensitive to penicillin. Sufficient strains of clostridia have not been tested to make any statements in regard to natural or induced insensitivity.

Four to 6% of strains of staphylococcus pyogenes were described as naturally resistant to penicillin by Sir Howard Florey, who also described *in vitro* development of penicillin resistance in this organism. Since that time, various reports of the incidence of naturally resistant strains of staphylo-



coccus pyogenes have been given, varying from 10% to 20%. Our own findings in regard to the incidence of penicillin resistant strains of staphylococcus pyogenes are:—

1. Forward surgical centres, before primary surgery, 13%.

2. Base hospital, prior to widespread introduction of penicillin therapy (May and June, 1944), 18%.

3. Base hospital, after the widespread introduction of penicillin therapy (September and October, 1944), but in cases not treated with penicillin previously, 28%.

4. Base hospital, in cases treated in the forward area, with a course of intramuscular penicillin therapy, average total dosage 550,000 units, 51%.

Any interpretations of the above figures are open to many criticisms, but we have felt that the figures of 13% and 18% above probably approximate the true incidence of naturally occurring penicillin resistant strains of staphylococcus pyogenes.

The figure of 28%, encountered more recently in cases not treated with penicillin, may possibly be explained on the basis of cross infection with resistant strains originating in penicillin treated cases.

The figure of 51% resistant strains in penicillin treated cases can only be explained on the basis of insensitivity induced by previous penicillin therapy. An attempt to learn factors determining the development of penicillin insensitivity in staphylococcus pyogenes has not as yet been successful. Nor have we yet discovered whether induced resistance to penicillin is maintained. One case only has been successfully followed. In this instance, staphylococcus pyogenes, originally sensitive to  $2\frac{1}{2}$  units penicillin, at the end of 6 days' continuous intravenous therapy was insensitive to 100 units penicillin.

The criticism may be made that our methods of determining penicillin insensitivity by the ditch plate method, using  $2\frac{1}{2}$  or 5 units penicillin per cc., are crude. In the study of soft tissue wounds we have observed, however, that staphylococcus pyogenes found insensitive by the ditch plate method has proven clinically insensitive to intramuscular penicillin therapy, and wounds sutured in the presence of insensitive strains of this organism have

invariably broken down. This also refutes the statement which has been made that penicillin insensitive strains of staphylococcus pyogenes are non-pathogenic.

### Summary and Conclusions

1. A course of penicillin therapy, consisting of a total of 550,000 units, administered intramuscularly every 3 hours during  $4\frac{1}{2}$  days in the forward area, has not altered the bacterial flora of the wounds.

2. The claim is made that this course of penicillin therapy has increased the incidence of penicillin insensitive strains of staphylococcus pyogenes. This claim is based on the statistical differences found in 114 strains isolated from cases not treated with penicillin, and 97 strains isolated from penicillin treated cases.

### Major-General Mitchiner

We are very grateful to Major Hamilton for his paper. I should like to know the effect of penicillin therapy on the diplococcus, and I urge you to be very careful of it. We feel that there is a little hope, perhaps, in the recent work of Lt.-Col. Baker published in the *Lancet*, where he advocates intermittent therapy, which I have seen practiced with very considerable success.

### Brigadier Edwards

I would like to ask a question on the definition of resistance. Do we understand by resistance that penicillin has no action, or is resistance a relative term, diminution of sensibility rather than complete insensibility?

### Major Hamilton

The answer to that is that we have not completed our investigations. I believe the resistance may be in varying degrees. We have examined some strains of staphylococci and found they would grow very easily in very high concentration of penicillin, and that the penicillin was without effect. We have found in other strains varying degrees of resistance. If we found a resistance strain we did not know whether it maintained the resistance or perpetuated that resistance. The problem is one which we have only just begun to study.

## CHRONIC SEPSIS WITH TOXAEMIA IN WAR WOUNDS

by

Lt.-Colonel R. A. KING, RAMC

The use of the modern chemo-therapeutic agents, penicillin and sulphonamides, has changed largely the aspect of war wounds. Healing is now amazingly rapid with thorough excision, followed by chemotherapy and delayed suture. Certain wounds, however, are slow in healing, because of infection of bone or joint. Others, grossly contaminated by metallic or other foreign bodies, develop infection, and may be long in healing. Infrequently, however, one sees a small proportion of chronic cases that

continue with discharge and pyrexia, become more and more toxæmic, and drift near to death.

It is with these severely septic and toxæmic cases that I am concerned in this paper.

One is unable to express an accurate opinion of the proportion in which such cases occur, as hospital units do not take all types of cases. I have collected from a base hospital a series of 28 severe chronic toxæmic septic cases, in a period during which approximately a total of five thousand surgical

cases were seen. These 28 cases were seriously ill, wasted individuals with pyrexia and anaemia of two to three months' duration. All had been in several medical units before reaching the base. Four were G.S.W. spine, with paraplegia, of which two died after several months. Twenty-five were compound fractures. Sixteen being femurs, five tibias and fibulas. Three had perforating abdominal wounds and four G.S.W. ilium. The majority had multiple large wounds. Five compound fractured femurs were associated with suppurative arthritis of the hip. Eight cases were associated with suppurative of the knee joint, and three of these also had compound fracture of tibia and femur at the knee joint. Total deaths were five. Spines, 2; abdomens, 2; severe multiple wounds, 1.

What were the causes of the prolonged infection and toxæmia in these cases?—

(1) In the first place all had multiple wounds, from mortar, shell or M.G. Many were extensive wounds, involving large areas of skin and muscle and extensively contaminated by metallic and other foreign bodies.

(2) Thirteen had suppuration of the hip joint or knee joint.

(3) Sixteen had compound fractured femurs.

(4) Secondary infections occurred in all, the predominating organisms being streptococci, staphylococci, *b. coli* and *b. proteus*.

(5) Intercurrent illness such as malaria, dysentery, pneumonia pyelitis, and pyelonephritis occurred in 12.

(6) Several had come to the primary operation at a very late stage, one after six days, several after 36 hours.

(7) The degree of chronic toxæmia was in direct proportion to the extent of the septic wounds.

(8) No case of secondary hæmorrhage occurred in this series.

(9) No cases of amyloid degeneration occurred.

### Treatment

It is a striking fact that out of this short series of 28 cases, further surgical drainage was needed in 24, and of these, 20 cases recovered, 15 are now ambulant, and three have now died.

Why was so large a proportion of cases in need of further drainage? Had they been neglected? No! on the contrary, they had had continuous and careful attention. Drainage had been obtained on them all in various units, but had not been continued for sufficient time.

Difficulty had been experienced in obtaining free dependent drainage, in some, because of the wound site and anatomical considerations. For example, deep wounds of the groin were drained anteriorly only. Suppurative hip joints were nursed with overflow anterior drainage and all the suppurating knees drained badly by ordinary methods. Some compound fractured tibias had large portions of bone missing; the resulting cavity, if on the front of the leg, did not drain well, pus collecting and overflowing. Several compound fractured femurs had infection tracking upwards to the buttocks, until the limb was well lowered to counter this spread by the aid of gravity.

By paying meticulous attention to obtaining free dependent drainage 20 out of the 24 cases operated upon recovered. Constant vigilance was necessary,

and most of them needed incision, on more than one occasion. In these severely emaciated and toxæmic patients, although free drainage was established, pyrexia fell gradually over a period of days or weeks; it rarely subsided suddenly. The general condition of these patients was improved by repeated blood transfusions. In several instances, cessation of pyrexia occurred immediately after blood transfusions; this fact sometimes was associated with mild rigors.

Large granulating areas were grafted as early as possible, and with the growth of epithelium improvement followed the diminishing area of septic absorption. Bone sequestra and all large foreign bodies were removed. In all cases complete immobilization was obtained by efficient splinting whenever possible.

Such chronic cases had to be assessed regularly and repeatedly, for drainage incisions sometimes had to be extended or repeated. In the case of limbs, the possibility of amputation was considered but it is significant of this series that no amputation was performed.

The most difficult part of the body to drain dependently was the knee joint (eight cases were dealt with). The majority had been continuously ill with swinging pyrexia for three months or over, and had hæmoglobin from 37 percent to 51 percent with much emaciation.

Owing to its anatomical peculiarities of contour, the synovial sac of the knee joint is not easy to drain. The main joint cavity is anterior, with a bifid synovial sac projecting backwards roughly at right angles to this, to accommodate the femoral condyles.

In cases of suppurative arthritis which come to arthrotomy, anterior incisions above and lateral to the patella into the supra-patellar pouch only drain by overflow. Attempts have often been made to augment this form of drainage. Posterior and postero lateral incisions have been made, but drainage of the knee joint in this manner is not, and cannot be, efficient, as the space between the femoral condyles and synovia is very narrow posteriorly. Secondary hæmorrhage is not unknown after posterior drainage by reason of the close proximity of the popliteal vessels. Moreover, each lateral compartment of the knee joint needs to be opened if posterior drainage is attempted. It can also be understood how inefficient such drainage is when one observes the fibrous masses contained in pus in some of these cases.

Attempts have been made to drain the knee in other ways. During the last war Willems successfully treated a series of suppurative arthritis by anterior incisions and continuous movement. Such treatment is painful and cannot be established where gross fractures are present at the lower end of the femur or upper end of tibia.

Again, complete transverse severance of patellar tendon and anterior coronary ligament has been advocated in the past with full flexion of the knee. This manoeuvre grossly damages the knee and is impracticable in the presence of fracture, and is associated with shock.

### Postural Drainage

*Efficient dependent drainage of the knee joint* can be obtained by the simple procedure of anterior arthrotomy combined with posture. The patient is turned over to lie face downwards.



The knee and leg are fixed in a plaster cast surrounding a massive cotton-wool dressing after the manner of Winett-Orr. Extension may be applied to the skin to control starting pains.

Patients are able to remain lying in the face-downwards position continuously for weeks and usually make steady progress; temperature drops, toxæmia diminishes, appetite returns, anaemia improves and they put on weight. I have found that, with this form of drainage, discharge is free, necessitating several changes of plaster for the first few weeks, after which time the plaster may be left for longer intervals, and changes governed by the patient's condition. Where the joint has been grossly infected, ankylosis is of course obtained with the knee in full extension.

The following points should be followed when nursing patients in ventral decubitus:—

(1) No pillow is needed for the head, otherwise the neck is too extended, but a pillow beneath the chest is appreciated.

(2) A relaxed position for the arms is obtained by placing the hands forward beneath the mattress, otherwise they should lie alongside the body.

(3) Both feet must protrude beyond the end of the mattress to prevent equinus deformity.

(4) The affected leg should be elevated slightly by slinging from a Balkan Beam, or a pillow should be placed beneath the foot.

(5) The normal knee should be supported at the lower third of the leg by a pillow to maintain slight flexion (the most comfortable knee position.)

(6) Attention must be paid to the anterior superior iliac spines and sternum, which become pressure points in the emaciated in this position.

(7) The position should be maintained continuously. The patient should not be repeatedly turned about. All nursing can readily be accomplished in this position.

### Chemo-Therapy in Chronic Sepsis

It has been found that the use of penicillin and sulphonamides in the presence of chronic sepsis is of little value until drainage is established. This fact was noticed with all the cases treated. When sensitive organisms are present and drainage is established, chemo-therapy however was then found of value. To illustrate the first point:—

One of the knee cases had had four arthrotomies, two courses of intra-articular sodium penicillin (10,000 units in five days and 80,000 units in eight days,) a course of 25 gms sulphathiazole and in desperation daily lavage of the infected joint with acriflavine and a series of blood transfusions. He continued with intermittent pyrexia for three months, by which time he was extremely ill and emaciated. A culture showed streptococci reported as completely sensitive to penicillin, together with an insensitive gram negative bacillus.

After a further arthrotomy in which three ounces of pus were evacuated from the knee, he was nursed lying continuously on his face for eight weeks. On two further occasions small pockets of extra-articular pus were drained. He had in this period two blood transfusions but no form of chemo-therapy whatsoever. In ten weeks he was walking on crutches and had regained his lost weight, the knee wounds had healed and the joint was quiet. He remains ambulant.

### Blood Transfusion in Chronic Toxæmia

The chronic toxæmic patient always develops secondary anaemia and a decrease in blood protein. Few of our cases had the blood protein estimated, but figures were recorded of between 6.5 and 8 gms per cent.

Hæmoglobin readings ranged between 37 per cent and 51 per cent.

Transfusion of whole blood was used to combat anaemia. Fresh blood was found to be desirable and was always used citrated.

When toxæmia and anaemia have persisted for many weeks, degenerative changes occur in the cardio-vascular system, as is proved by cases that come to P.M. If long continued, anaemia and toxæmia cause myocardiac degeneration and changes in vascular endothelium, permitting increased permeability. Under these circumstances blood transfusion may be dangerous; it may lead to acute cardiac dilatation oedema of lungs, and death from overloading of the circulation. For this reason, when toxæmic cases are transfused, it is absolutely essential for blood to be given very slowly, about 20 drops per minute. Some authorities prefer to give a series of small intermittent transfusions of only half a pint at a time at intervals of a few days.

The general condition of patients was usually vastly improved by transfusion, as shown by recovery of appetite and improved mental outlook. In some cases pyrexia fell immediately afterwards, and from that time remained normal. Amounts of one or two pints of fresh citrated blood were given by slow continuous drip at weekly intervals until hæmoglobin was between 70 and 80 per cent. Rigors were not common, but one case had a temperature (104) after blood, and lost his old continued pyrexia from that time.

In conclusion, careful attention to diet, the administration of vitamins, iron preparations, and expert nursing were important factors making for recovery in these cases of chronic toxæmia, without the prolonged and skilled devotion of the nursing staff many of such ill cases could not have recovered.

### SUMMARY

(1) A short series of chronic septic war wounds with toxæmia is reviewed.

(2) The majority of cases had heavily infected and large multiple wounds involving bone and joints.

(3) In the treatment of these cases surgical drainage was needed in 86 per cent.

(4) The peculiar difficulties of surgical drainage of the knee joint and the advantages of postural drainage are described.

(5) It is pointed out that chemotherapy in chronic sepsis is of itself of little value until surgical drainage is efficient.

(6) The risks of blood transfusion in chronic sepsis are minimised by the slow administration of blood. Its advantages are endorsed.

*Major-General Mitchiner*

We have to thank Colonel King for a complete exposition of the well-known engineering principle that if you want to empty a tank, it is advisable to do so from the lowest part.

*Brigadier Rowley Bristow*

I would just like to pay tribute to what Colonel King has said, because I had the privilege of going round the hospital with him last year seeing some of these cases, and hearing of some of the results he was getting, particularly in dependent drainage of the knee. I have been privileged to spread that gospel in other quarters, where it has been very well received. This problem is fortunately at the present time not very prevalent amongst cases as they came back to us in England. I was the other day at a centre which receives cases from Belgium, and they had had 15,000 patients in transit. Of that number 78 were penetrating gunshot wounds of

the knee. Roughly half were without bone involvement. Twenty-two had bone involvement of the tibia similar to Colonel King's picture, and 22 had involvement of the lower part of the femur. Actually they had had to carry out four amputations. Two of these four had gas gangrene, one following ligation of the popliteal artery, and two only were amputated for sepsis. As regards nursing patients in the prone position, I entirely agree with Colonel King. After the first two or three days the patient gets used to it and the problem presents no great difficulty. I would express thanks to the reader of the paper and cordially agree with his findings.

## ABSTRACT OF TREATMENT OF 1,000 JAW WOUNDS

by

Major PATRICK CLARKSON, RAMC,

Major T. H. H. WILSON, A. D. CORPS

and

Capt. R. S. LAWRIE, RAMC.

(Read by Major Patrick Clarkson)

This paper describes 1,000 jaw fractures treated in two years. They represent the jaw fractures in over 3,000 maxillo-facial casualties treated by the unit. These jaw casualties come from the Tunisian, Sicilian, and Italian campaigns.

### Site of Work and Development of Forward Maxillo-Facial Surgery

In North Africa, the cases were received late. Intermediate and long-term treatment was given at the main base at Algiers. Specialised forward treatment was limited to dental fixation.

In Italy, the early treatment of the soft tissues was developed at a general hospital functioning 50 miles from a static front. This treatment comprised (as well as the fixation of the bone fragments) the primary closure after excision of wounds suitable for it (20 to 30 per cent of all M.F. casualties). It also provided specialised anaesthetist services by which accidental deaths are avoided in these cases. Subsequently, a section moved with the Army to continue this work, with special reference to early return to duty (in four to eight days) after excision and suture of suitable facial wounds.

### Scope of Analysis

The present analysis is primarily concerned with determining rates of union and incidence of infection in different types of fracture, and the influence on these of:—

1. Time and type of jaw fixation.
2. Treatment of the comminuted bone fragment.
3. Treatment of the involved teeth.

### Type and Cause of Injury

Seventy per cent of these 1,000 cases were missile wounds, of these mortar caused about 40 per cent, shell and gunshot 30 per cent each, and grenades and bombs less than 5 per cent each.

Closed injuries were 30 per cent of these cases; these were mostly accidents (including battle accidents).

Six hundred of these 1,000 cases were seen through to union and return to duty in the Mediterranean Forces; 400 were evacuated to U.K. after one to two months' treatment.

### Principles of Treatment

Treatment adopted fell into three phases, early, intermediate and late.

#### EARLY TREATMENT

The more that is done early, the less has to be done later and the quicker is the final repair.

(a) *Fixation*.—Early fixation was by wire or, for the minority, splints. Fixation should be undertaken during the first two days; but intermaxillary fixation (I.M.F.) should be delayed in presence of damage to tongue and pharynx with much swelling, and in presence of nasal obstruction.

(b) *Comminuted Fragment*.—At primary operation a meticulous removal of all displaced bone in the tract and around the fracture site is done. Bone fragments at fracture site which might live are always left. In maxillary fractures there is great conservatism with major alveolar fragments and with the floor of orbit; this is combined with a radical removal of comminuted antral wall, and establishment of large nasal antrostomy when the missile has not already done this.

(c) *Teeth*.—In accidental fractures all involved teeth except, firmly imbedded incisors are removed at primary operation. For comminuted shell fractures a more conservative policy is adopted except for loose teeth and those easy to extract.

(d) *Soft Tissues*.—Clean wounds, including pharyngeal wounds, of up to 24 to 36 hours old are treated by a meticulous and minimal excision and



the best cosmetic closure that can be done without prejudice to any late repair which may be necessary. Up to 30 per cent of cases are suitable for a primary final repair. Mandible fracture sites are drained through the wound. Separate stab drains are not used. Haemorrhage has always been controlled by a local attack on the bleeding point.

(e) *Feeding*.—In difficult cases Ryles Tube is used for one to three weeks to maintain nutrition. Only four gastrostomies were done in 1,000 cases.

(f) *Airway*.—It is sound military practice to do a tracheotomy on any M.F. casualty with upper respiratory obstruction not relieved by a toilet of mouth, pharynx and nose, especially under busy conditions or when evacuation is unavoidable.

It must be done: (1) in emergency, for acute respiratory obstruction if a tube cannot be passed; (2) in wounds of pharynx or larynx after primary closure; (3) when Inter Maxillary Fixation is necessary in presence of gross intraoral damage or nasal obstruction.

Laryngotomy is reserved for cases of most extreme emergency.

#### INTERMEDIATE TREATMENT

This is the treatment of infective complications of bone and teeth, and the provision of definitive fixation by splints for most of the cases fixed early by wire. Conservative sequestrectomies without radical exposure are done during the first six to eight weeks. A small minority of wounds not then dry are explored radically and all bone not certainly living cleared out.

Secondary hæmorrhage: There were six arterial gushers (1 per cent) of missile wounds) in this series. All were controlled by proximal ligation of the external carotid on the same side. None died.

#### LATE TREATMENT

In Algiers and Naples, this has consisted of scar corrections which have been done one to four weeks after final healing, cancellous chip bone grafts, one to four weeks after healing and two to three months after the day of wounding, and epithelial inlays for 5 per cent the missile wounds returned to duty in this theatre.

#### Methods of Treatment

Wire, which has been used for 500 cases, has been the routine method of early fixation. Splints have been used for 397 cases (847 splints fitted). Most cases treated early by wire have been changed on to splints during the intermediate phase of treatment. Splints have been used for forward primary fixation only in presence of scanty dentition, unusual occlusion, and certain multiple fractures. The chief disadvantage of forward splinting as a routine early treatment has been that teeth have been included in the splint which have to be later extracted. Furthermore, construction of splints is best left to more deliberate conditions where the case can be held and fully X-rayed.

Per-alveolar and circumferential wiring has been used for 45 edentulous cases; external Roger Anderson pins for 15 cases with posterior edentulous fragments compound into the mouth; interosseous wiring for 15 cases of angle fracture not compound into the mouth; and headcap fixation for 38 cases of maxillary fracture. These methods are discussed, the results, and the role in which they were used are described.

#### Results

Both shell and accidental linear fractures of the horizontal ramus involving teeth united in 45 days. In both groups the effect of comminution was to prolong union time, but only by about 20 days. The slight to moderate degrees of comminuted fractures united in 62 days, the grossly comminuted shell wounds united in 64 days. The result in both accident and shell groups of delay in fixation was to prolong the union times for one to three weeks; the more comminuted the fracture, the more adverse was the effect both on union times and incidence of infection of late fixation and surgery.

Union delayed beyond 90 days was present in seven cases in the accidental group, all these cases united in 150 days.

In the angle fractures involving teeth the effect of comminution is the same. Union times vary from 39 days for linear fractures, to 59 days for shell-comminuted fractures. As was the case of the horizontal ramus, fractures with comparable degrees of comminution show similar union times whether the cause was a blunt injury or a missile.

*Ascending Ramus, Condyle and Coronoid Fractures*.—There were 49 fractures of the ascending ramus, 128 fractures of the condyle, and 25 fractures of the coronoid. All fractures of the condylar neck returned to duty in a month after three weeks immobilisation. Trismus was a major complication only in the coronoid wounds.

There were 59 cases of incomplete fractures of the mandible. A high proportion of these cases were returned to duty within a week following radical bone clearance and primary closure.

*Fractures of the Maxilla*.—Eighty per cent, of 260 maxillary fractures were due to missile wounds. Twenty per cent, of the shell wounds had mobile or floating maxillæ, and were treated by intermaxillary fixation and P.O.P. headcap fixation. These all united clinically after a month's fixation even in those cases where fixation was delayed for a fortnight. Fifteen per cent, of shell wounds showed evidence of antral disease, but in only 2 per cent, was the condition chronic. For these a Caldwell Luc operation was done after six weeks. In the accidental fractures antral infection was 8 per cent, and 4 per cent, had Caldwell Luc operations. This incidence of antral disease covers only the first three months.

*Deaths*.—There were 33 deaths in the series. In only 15 was the maxillo-facial injury the cause of death. In nearly all the others the cause of death was an associated neurological injury.

In mortality of the pure M.F. injury was 15/1,000, 1 to 2 per cent.; about 1.5 per cent. for missile wounds, and less than ½ per cent. for closed injuries. The pure M.F. deaths were more common in the first week than after the first week.

The mortality from the pure mandibular wound was less than ½ per cent.; from the closed mandibular injury, none in this series. In cases that reach C.C.S. level the chances of death early are greater than late. Respiratory obstruction and hæmorrhage are the cause of death in the first week; respiratory complication are the commonest cause after the first week.

### Discussion.

*Time and Type of Fixation.*—Evidence presented shows that fixation (combined with thorough surgery) within two days is desirable because union times average 20 days earlier than when fixation is delayed beyond the second day. The incidence of inflammatory complications in cases fixed early is reduced by 60 per cent. The more gross the comminution, the more marked is the benefit of early fixation.

*Type of fixation:* The experience of this unit is that splints give the best fixation, but that wire is usually best for early forward treatment.

*The Comminuted Fragment.*—In jaws fixed within a week this is the most important single factor in determining the period of union. But with orthodox and thorough treatment the effect of comminution is not great, only about 20 days' delay in union times.

Ninety cases of diffusely comminuted fractures of tooth bearing horizontal rami have been followed to union in average of 60 to 65 days. These cases have not been treated by radical clearance of all comminuted fragments, but only by a thorough removal of all obviously dead fragments and dead soft tissues, combined with early firm dental fixation.

*Time of Extraction of Involved Teeth.*—Extractions of involved teeth at primary operations have been conservative for the comminuted shell fractures, and routine for the linear accidental fractures. Late extractions have been done to remove the cause of chronic infection and never for the purpose of averting it. In 480 cases of fractures involving teeth these late extractions were necessary in 15 per cent. of the cases.

*Penicillin.*—There is no evidence that parenteral penicillin has reduced infective sequelæ in a fracture which involves teeth and communicates with the mouth, but for early facial closure penicillin can definitely reduce the incidence of suture line infection.

### Major-General Mitchiner

On your behalf and my own I extend to Major Clarkson grateful thanks for such a complete exposition of the hard work he and his dental colleagues have done, for which many men will be grateful, and their women-folk as well. On Monday I understand that Lt-Col. Raven's paper on "Factors Influencing the Closure of Battle Wounds" was unavoidably held over. Brigadier Edwards allows me to say that this is a good time to ask Colonel Raven to deliver his paper if he is here and prepared to do so.

## FACTORS INFLUENCING THE CLOSURE OF BATTLE WOUNDS

by

Lt.-Col. R. W. RAVEN, RAMC

The surgical management of wounds sustained in battle has undergone considerable evolutionary change during the development of the war, with obvious and marked benefits to the patients. Those who have studied the end — results of the various methods of treatment employed both now and in the past cannot be otherwise than impressed with the present technique. Wounds are now soundly healed after a period of two or three weeks as compared with the two or three months with other methods; the quality of the healed scar is superior to the extensive scarring which resulted from healing from granulation, and patients who used to be evacuated to base hospitals with the possibility of going to the United Kingdom are now sent to convalescent depots with the probability of returning to active duty. The conservation of effective manpower is therefore obvious. Another notable feature is the marked reduction in the incidence of foul, suppurating wounds with the presence of constitutional toxæmia. The surgical vision of surgeons of the 1914-1918 war has been vindicated, and the truths propounded by them concerning the closure of wounds have been recovered. Let us hope that the lessons we are learning during the present war, in surgery and in other fields of human endeavour, will never again be lost sight of.

In the planned treatment, culminating in the successful closure of battle wounds of all types, two surgical teams make a contribution of equal impor-

tance. We pay tribute to the excellent work of colleagues in forward areas resulting in patients reaching base areas in a suitable condition for closure of the wound to be successfully performed. The results in a series of cases are set out at the end of this paper. The main object of this communication is to bring forward the factors which have contributed to the success achieved.

### The Primary Operation in the Forward Area

There are certain important factors in the conduct of the primary operation which influence the subsequent treatment and the following are reiterated.

#### Adequate incision of the wound

This applies to skin and deep fascia; free drainage of the depths of the wound must be established. If possible, the skin incision should be planned with a view to early closure. No skin which is likely to be useful must be sacrificed. Longitudinal incisions are preferable to transverse incisions in the lower extremity; two incisions transecting each other are very unsatisfactory and the skin flaps should not be sutured back otherwise nutritional changes occur in the skin. Muscles involved in the wound are decompressed and tissues irreparably damaged should be excised. It is our opinion that metallic foreign bodies should be removed if possible. Pieces of clothing are frequently attached to shell fragments and they are a potent source of infection. We have



operated upon a number of such cases, in fact the majority of wounds which we found unsuitable for delayed suture without further treatment were due to these metallic fragments. The difficulties attending their accurate localization in forward areas are obvious, but the ill-effects of their presence, especially in wounds involving bone or joint, are stressed. In the dressing of wounds, vaseline gauze coverings and vaseline gauze packs are best avoided, dry gauze with cotton wool held in position by a well-applied calico bandage or plaster bandages forms the best dressing. Dressings must on no account be disturbed to inspect the wound along the line of evacuation unless some complication is present which demands urgent surgical treatment. No examination of the wound is made until the patient is in the operation theatre for delayed suture.

#### **Treatment in the Base Area**

It is advisable for the patient to reach the base area for delayed suture during the period three to seven days following the primary operation. We have closed wounds successfully long after this period has expired but in the period named the tissues are in the optimum condition for closure. Credit is due to the medical administration for the successful evacuation of casualties which has ensured that the majority of patients have been brought back so quickly. In the base area there are certain factors to be considered and are dealt with as follows:—

#### **The General Health of the Patient**

The factors which contribute to the maintenance of general health must be studied, especially in patients with extensive wounds.

#### **The Water Balance of the Body**

This is frequently deranged in the severely wounded man, and must be corrected early. Abnormalities in this respect exert deleterious effects upon the healing of wounds. In anhydræmia there is a decrease in the blood volume, peripheral vasoconstriction, increased viscosity and stagnation of the blood with decreased volume flow through the tissues leading to anoxia, and malnutrition of the wound. Sub-oxidation decreases the rate of tissue metabolism, altering the form, speed and direction of the chemical reactions responsible for healing. The effects of hyper-hydration are similar to those of anhydræmia, the tissue oedema which results interferes with venous return and congestion occurs.

#### **The Blood Picture**

##### *Protein Deficiency*

This condition is a manifestation of a poor nutritional state, and must be suspected in patients who have suffered from an acute injury, severe hæmorrhage, or when other lesions, such as severe burns, are present which cause extensive plasma loss. In patients thus affected delayed wound healing or disruption of the wound are seen. There is sub-normal fibroplasia; in experimental wounds it was shown that fibroblasts did not appear until the seventh day. In the interpretation of plasma protein determinations two pitfalls are to be remembered. Dehydration increases the value for the total protein as well as the albumen, thus masking the presence of a true deficiency. The total amount of circulating plasma protein may be reduced, yet, because of dehydration, concentration may approach the nor-

mal. Secondly, the measurements of total protein may be normal in spite of the albumen fractions being markedly depleted. These pitfalls are avoided by obtaining hæmatocrit values and by carrying out fractionation. In the correction of milder degrees of hypoalbuminæmia dietary replacement may be sufficient. Thus the patient is placed on a high protein diet with foods containing all the essential amino-acids, such as milk, lean meats, egg proteins and soya bean protein. In more severe deficiencies replacement by means of plasma transfusions is necessary and adequate amounts must be given. The oral and intravenous administration of amino-acids is important and valuable. Our American colleagues are carrying out work on this subject with interesting results. The use of amigen and other compounds will replace much of the excessive loss of nitrogen which follows trauma.

#### **Secondary Anæmia**

This condition is frequently seen in patients with severe wounds and must be corrected as early as possible. In such cases it is our practice to institute blood transfusion if the hæmoglobin content falls below seventy per cent.

#### **Acidosis and Alkalosis**

The reaction of a healing wound is acid and the vasodilatation essential for wound healing is maintained at p.H. values between five and seven. Above and below these p.H. levels vasoconstriction occurs. In the healing process vasodilatation and a moderate degree of acidity are probably responsible for the exudation of cells and plasma colloids from the blood capillaries. Proteins, such as fibrin, are essential for the formation of the bridge-work of wounds. Further, the action of autolytic enzymes is dependent upon an acid reaction and this also facilitates repair by producing more complete dissociation of oxygen. The interesting observation has also been made that the wounds of animals fed on an alkaline diet swarm with bacteria.

*Vitamins.* Experimental evidence has been adduced concerning the rôle of vitamins A and C in wound healing, but it is probable that vitamin lack must be of long duration before deleterious effects are produced in wounds. This deficiency, if present, can be easily remedied.

*Fever and Toxæmia.* This denotes the presence of suppuration in the wound probably due to retained foreign material with inadequate drainage. It is corrected by the appropriate surgical measures combined with penicillin therapy, both local and general over a period of three days. At the end of this time we have found that the wound is suitable for delayed suture.

#### **Closure of the wound by delayed suture**

Every effort is made to ensure that the patient is in the optimum general condition when this procedure is carried out. In all cases of penetrating wounds and all wounds of bone and joint radiological examination is made to localize metallic foreign bodies and assess the extent of bone damage. In carrying out the operation the following technical factors are important.

#### **Preparation of the skin**

In the majority of battle wounds the skin around is infected. Bacteriological examinations have been made in a series of twenty wounds in order to



determine the type of infection which is present. In four cases the skin was sterile; *B. subtilis* was isolated in ten cases; *staphylococcus aureus* in four cases; diphtheroid bacilli in three cases; *staphylococcus albus* in two cases; *micrococcus tetragenus*, in one case, and coliform organisms in one case. It was also found that the wound may be sterile and the skin around it infected. Meticulous care is given to the care of the skin around the wound in order to provide a sterile field of operation. The following routine is carried out in all cases. Any hair which is present is shaved off a wide area around the wound, and the whole limb or other region involved is washed with soap and water using a brush followed by ether methylated, and lastly surgical spirit is applied over a wide area around the wound.

### The Surgery of the Wound

The wound is gently mopped with warm normal saline to remove any exudate or blood clot. It is advisable to extract metallic foreign bodies, especially those more than one quarter inch in size, unless this entails extensive dissection. This applies with greater force in wounds involving bone. Traumatized and devitalized tissues are excised, for if left behind numerous islets of necrosis occur. The presence of each ligature also produces an additional islet of necrosis. It is unnecessary to ligate the smallest blood vessels; these can be controlled by the pressure-dressing applied at the end of the operation. The wound is incised at both ends so that these extremities can be accurately approximated. The skin edges are freshened by removal of a small strip of tissue one eighth inch wide using scissors, care being taken that healthy skin is not sacrificed unnecessarily. Bacteriostatic chemicals must be used with care. The wound is powdered with penicillin-calcium sulphathiazole powder which is gently massaged into the tissues so that it reaches all parts of the wound. Sufficient powder to provide a thin coating over the tissues is used. In massive wounds involving bone it has been our practice to supplement local penicillin-sulphathiazole therapy with a course of parenteral penicillin sodium. In wounds of joints the solution is injected into the joint cavity. The wound should be sutured without tension in order to avoid necrosis at the suture line, hence, undercutting of the skin and subcutaneous tissue to varying degrees may be necessary. Closure of the skin is carried out with interrupted sutures of finest Nylon material using fine cutting needles. Nylon is superior to thread and other forms of suture material. The needle is entered through the skin one quarter inch from the edge, and the sutures are spaced three eighths inch apart. No buried sutures are employed, and accurate apposition of the skin edges is essential. We seldom drain a wound; in any case a large drainage tube should not be used as it acts as a foreign body. For the obliteration of dead spaces we rely on a pressure-dressing applied carefully. During operation, steps are taken to prevent air-borne bacterial contamination of the wound. Dehydration of the wound from excessive exposure to the warm, dry air of the operation theatre and the heat of the lamps should be avoided. If much tension is required to close a wound, partial suture is performed, leaving the middle part to be covered with a skin graft after a few days. Every effort is made to cover the exposed tissue as soon as possible.

### Dressing of the Wound

#### Care of the Skin

Blood clot is removed with saline, the skin is dried and lightly powdered with proflavine powder followed by surgical spirit. The skin around the wound is covered with a fine layer of a mixture of zinc cream and ichthyol in equal parts. The preparation is valuable in the treatment of the "blotting paper" type of skin surrounding certain wounds. A double layer of dry gauze is placed over the area, covered with a liberal amount of cotton wool and the part is firmly bandaged using calico bandages. By this means dead spaces are obliterated, tissues are supported, and the part is kept at absolute rest until the sutures are removed on the eighth post-operative day.

In certain situations such as the antecubital and popliteal fossa tension in wounds is diminished by flexion of joints, the position of the limb being maintained by plaster bandages. The dressing should not be touched until the sutures are removed, unless there are indications for inspection, and this should be carried out in the operation theatre. After sutures are removed two or three days are allowed for consolidation to occur thereafter rehabilitation is instituted.

A study has been made concerning the results of delayed suture in 291 consecutive patients; 61 of these had multiple wounds so that the number of wounds treated is 417. The series has been divided into two groups, A — Wounds of soft tissues and B — Wounds of soft tissues and bone. The results are set out in the following tables:—

Table 1. Wounds of Soft Tissues. Total number 363.

Degree of healing									
100 %		99-90%		89-80%		79-70%		Below 69%	
No.	%	No.	%	No.	%	No.	%	No.	%
316	87.0	41	11.2	3	0.8	0	0	3	0.8

It will be seen from the figures in table 1 that in 98.2 per cent of cases healing of the wound to the extent of 90 per cent and above occurred.

Table 2. Wounds of Soft Tissues and Bone. Total number 54.

Degree of healing									
100 %		99-90%		89-80%		79-70%		Below 69%	
No.	%	No.	%	No.	%	No.	%	No.	%
35	64.8	12	22.2	2	3.7	1	1.8	4	7.4

It will be seen from the figures in table 2 that in 87 per cent of cases with wounds involving bone healing to the extent of 90% and over occurred. As expected the end - results when bone is involved are



not so good as when soft tissue alone is affected. All the same the healing figure for bone cases is most gratifying.

### Conclusions

The factors concerned in the successful closure of battle wounds are discussed in detail. The operative treatment is divided into two stages — the initial operation conducted in the forward areas and the second operation at the base. The planned treatment involves meticulous attention to detail. The maintenance of the patient's general health plays an important part in the healing of wounds. The results achieved are most gratifying, representing as they do a marked conservation of manpower and diminished morbidity.

### Appendix

The results achieved represent the work carried out in the Surgical Division by Major T. Levitt, Captain D. G. Morris and the writer, ably assisted by all the other members of the team—surgical and nursing. I wish to express my thanks to Colonel W. A. Y. Knight, A.M.S., for kind permission to publish the statistics.

### Major-General Mitchiner

I am sure you will wish me to thank Colonel Raven for so emphatically and forcefully reminding us of the principles governing the surgery of the closure of wounds. I would ask Capt T. B. McMurray to speak on parachute injuries of which I understand he has considerable personal experience!

## INJURIES AROUND THE ANKLE JOINT OCCURRING IN PARACHUTISTS

by

Capt. T. B. McMURRAY, RAMC

A large proportion of parachutists become casualties before they get the chance to take part in a battle. Dropping accidents occur both in practice and combat jumps, and the potential accident rate is of tremendous importance when planning an operation.

By teaching the men how to land the casualty rate has been considerably reduced.

The modern method of landing as taught to the potential parachutist is very simple. It has two main rules. First that the feet, ankles and knees are kept tightly pressed together, to that at the moment of landing the weight is evenly distributed between both lower limbs.

Secondly the recruit is taught that he must not try to land standing up but must collapse into a roll. This takes a lot of training, but is essential since the roll with its momentary foot balance takes considerable strain off ankles and knees.

Owing to the unevenness of the ground; excessive drift or oscillation due to wind, or that the man has opened his legs during the descent, one foot may hit the ground first or hit it a glancing blow. This often causes sufficient damage to make him a casualty.

There are several injuries peculiar to parachuting, but by far the greatest number occur in the region of the ankle joint. These must be considered from two points of view.

First is whether the injury is so severe as to prevent him getting off the dropping zone by himself without the aid of others for unless he is able to do this he stands a good chance of being picked up by the enemy.

Secondly is the problem of whether, after treatment, he will be able to be classed as a fit parachutist, and what will be the period of his disability. This is of importance, since C.O.s are always anxious to know whether it is worth while keeping an injured man on the strength of their units.

In assessing the immediate disability of an injury in the region of the ankle joint the cases fall naturally into two groups. Those where the trouble affects the weight bearing line and those where it does not.

In the latter group the disability does not prevent his locomotion initially but may have effect later, while in the former he is unable to walk from the time of injury.

This is seen particularly in fractures of the fibula, where a man will walk a considerable distance until such a time as effusion takes place into the ankle joint and weight-bearing on this foot causes stretching of the capsule anteriorly and considerable pain.

Fractures in this region are common, and do not differ much from every-day accidents. There are however two facts worthy of note.

First, fractures of the astragalus are rare in parachutists. In two years I only saw one due to a parachute drop.

Secondly, there is a specific parachute fracture described by the Americans. It is a fracture of the lower third of fibula with backward subluxation of the astragalus and fracture of the posterior lip of the tibia. This is often unaccompanied by damage to the internal malleolus or to the medial collateral ligament. Sprains of the ankle have seven common possible components.

1. First and most common is the strain of the anterior fasciculus of the external lateral ligament. One can usually see the characteristic hæmatoma eight minutes after the accident has taken place. The disability is slight and the condition cures itself in five days. The important thing is to keep the ankle moving, and the man is encouraged to use it to the full. We did not find local anæsthetic to be of much value.

2. Strain of the attachment of the external lateral ligament to the external malleolus. This is a more serious condition and requires strapping in eversion



with a pad of felt under the outer side of the heel. After this has been done the man can continue walking, with frequent rests, until such a time as effusion into the ankle makes this impossible.

It usually takes about three weeks until he is completely free from symptoms.

Rupture of the external lateral ligament is accompanied by early œdema and massive bruising, and these cases will not weight-bear even in the most stimulating of circumstances.

3. *Strain of the inferior Tibio-Fibial Joint.*—This is by no means an uncommon component of the sprained ankle. It is probably caused by forced dorsi-flexion of the ankle joint. Normally in the erect standing position the weight is borne from the under surface of the tibia directly onto the upper surface of the astragalus, but when the foot is dorsi-flexed, as in walking, considerable strain is thrown onto the ligaments supporting the inferior tibio-fibial joint, and if this is strained it may give rise to a lot of pain. The interesting fact about these cases is that they often find it easier to run than walk. It is impossible to diagnose this condition by X-ray, since the displacement is minimal, but it may easily be recognised by a simple test.

The malleoli are strongly pressed together by the palms of the hands with fingers interlocked behind the ankle joint.

The foot is then gently pushed up into dorsi-flexion. Pressure over the malleoli is now suddenly released, and the patient feels a spasm of pain right across the ankle.

By this method it is possible to distinguish between this condition and fluid in the joint, since the pain of the latter comes on during the movement of dorsi-flexion and is usually diminished when one lets go.

During the early stages of this condition, as long as the foot remains in plantar flexion, presenting the narrow posterior end of the articulating surface of the astragalus to the tibio-fibular mortice, the patient remains comfortable. Therefore, if the heel is raised by placing a one and a half inch pad under it inside the boot, one can expect a fair amount of walking during the next four hours.

The treatment is simple. Rest in bed, with elevation initially to reduce œdema, and active non-weight-bearing exercises after 48 hours. It is essential, however, to keep the patient in bed until forced dorsi-flexion no longer produces pain, otherwise they often complain of pain for many months, particularly after long marches.

The more severe condition of complete diastasis without bony damage is also seen; it is due to backward dislocation of the astragalus. It is easily recognised by means of a pair of machine calipers placed over the malleoli. The normal play during the movement of the ankle from plantar to dorsi-flexion is under  $\frac{1}{4}$  in., but may be as much as  $\frac{3}{4}$  in. In diastasis the range is increased and comparison of the two ankles will soon show it up.

The condition is crippling in its immediate effects, and later due to instability.

4. *Strain of the Internal Lateral Ligament* is also a frequent accompaniment of lesions around the ankle-joint. It is always a subsidiary factor to a

more severe lesion on the outer side. In fact, if there is tenderness present over the internal lateral ligament and none over the external, it is almost indicative of a fracture of the fibula at a higher level.

5. *Tenosynovitis of the Tendon Achilles* of traumatic origin sometimes accompanies severe ankle injuries and also may appear by itself. The point of maximum tenderness is near its insertion into the os calcis. It is usually caused by forced dorsi-flexion and is not seriously incapacitating.

6. *Tenosynovitis of the Long Extensors* of the toes. It is caused by forced plantar flexion. It is characterised by fluctuant swellings above and below the anterior annular ligament. This may give rise to a lot of trouble, particularly if the patient has to wear boots. It subsides in two or three days with rest, and if he wears gym shoes during the next four days it usually prevents a recurrence.

7. *Tenosynovitis of the Tibialis Posterior* may also occur, but it is secondary to other conditions and rarely gives any trouble.

It has been found necessary in action to leave dropping casualties where they lie, since medical orderlies during the initial period of landing have to carry a large personal load of vital supplies. For this reason we are equipped with a type of walking caliper which can easily be fixed to a man with a damaged ankle and make him mobile enough to get himself off the dropping zone.

#### *Major-General Mitchiner*

I am sure you will wish me to thank Capt McMurray for his able discourse on parachute injuries. Before vacating this chair to Brigadier Edwards, I would thank you for having done me the honour of allowing me to occupy it this afternoon.

#### *Brigadier H. C. Edwards*

I should like to take this opportunity, the last one I shall have, to say one or two things. The question of the meeting tomorrow—there is some misunderstanding as regards officers commanding field surgical units. Such officers still in Rome we shall be glad to see present. I have been asked what is to be done with the material discussed at this conference. It is proposed, and I hope it will be possible, to put into book form the various papers and also the discussions, and Colonel Latchmore has gathered them together for this purpose. If anyone would like to alter his material, perhaps he would communicate with myself or Colonel Latchmore, but I would remind you that what you have said is going down. Colonel Latchmore asked me if I would let you have the papers back. Not on any account! You will no doubt have copies of your papers, and if you edit these and send in the new edition, please do so as soon as you are able.

Before asking General Stayer to close this conference, I would just like to express your thanks to the large number of people who have been helping so heartily with this event. I have to thank Brigadier Low of the Rome Area Allied Command, Colonel Douglas Inch, ADMS, and his indefatigable DADMS, Major MacLeod. I would also wish to thank Signor Gaspardi for letting us have the use of this hall, and Professor Pantaleoni for the loan of the photographic apparatus. I would also like to thank the



Commanding Officers of the Rome Hospitals, Colonel Russell, Colonel Garraway, Colonel Croft. Colonel Croft has turned his hospital into a hostel for this meeting. Also Colonel Kirk-Bryce, commanding the 30th Indian Hospital, and to others like Major Toland, in charge of the Information Bureau, Lt.-Col. Rodgers, who has done many things (when he agreed to look after the lavatory accommodation I realised the versatility of the British surgeon), Lt.-Col. Latchmore and Capt. MacLean. Behind these doors are many people working, and we have a

body of other ranks to whom I would like to express your gratitude. Amongst them, S/Sgt. Evans, who has made his sleeping quarters in this building, and my own clerk, Sgt. Wade, who has done so much donkey work. I feel I have left many people out. I know they will forgive me, for it is such a long list, I cannot mention every one of them. I would finally like to mention in particular Lt.-Col. Capper, whose work in this connection has been prodigious. I will now call on Major-General Stayer to close this conference.

## CLOSING ADDRESS

by

Major General M. C. STAYER, Surgeon

*Mediterranean Theater of Operations, United States Army*

General Hartgill, Brigadier Edwards, Gentlemen:

It has been a great privilege to be here and take part in your discussions. I personally think it a great privilege because I have been a participant in wars since 1898, and in that time I have seen amazing advances take place in our profession. Out of my experiences in the Spanish-American War I could tell you many appalling stories about the medical profession of that time.

This week you have heard of some of the things our profession is doing today. It would be difficult in the space of a few minutes to relate them all, but manifestly the training of our doctors has progressed beyond our wildest dreams. You have seen and heard of a number of the outstanding procedures this theatre has produced. You have taken part in these and can be proud that this theatre has been able to pool its experiences and from them evolve procedures which are making history. I have been in other theatres and have seen what they have done, but it is only by your training and your experience here that many significant advances have been effected.

I feel that at this time I should pay tribute to the young surgeons in forward areas, who, by their skill, their courage and their will-to-do, have given our men the morale to fight. When the soldier goes into battle he carries with him the assurance that if he is wounded he will, possibly within a few minutes, receive the benefit of the finest medical procedures the world has yet seen. You who have been privileged to go into forward areas have seen those men come in dreadfully wounded, in deep shock, and have then seen what our people did—our surgeons, our nurses and technicians working around the clock. You have seen men almost moribund who, by the use of plasma, whole blood, penicillin, the sulfa drugs, and, what is paramount, good general surgery, good pre-operative treatment, good post-operative treatment, so recovered in a few days that you might have wondered if they ever had been wounded. They *look* so well.

I should like to repeat to you two statements I heard recently about our profession.

I was in Washington at a luncheon attended by some of the highest military notables. I was proud for you and me as members of our profession when several persons told me that the medical services of our theatre were beyond criticism. We had accomplished things nobody had ever thought we could, in bringing back the wounded, who years ago would have met death, to be useful citizens of the world.

A second instance. Recently I attended a decoration ceremony and heard an Air Force Commander publicly express his gratitude to the medical profession and its co-workers for giving his gravely-wounded men a new outlook on life. He went on to express the opinion that there is no other service which compares with the medical. You and I can feel a real pride in such a service.

I think the medical and surgical congresses we have attended here have been extremely valuable. It is fine to hear many of our younger surgeons ask us why a thing should not be so-and-so. This is a stimulus to all of us to go forward and do even better. We have heard in our meetings, over these five days, many a problem which has not been solved. After many years—close on 50—I have seen the amazing difference in the training of medical men in, say, the last 25 years as compared with the first. I am confident that the questions put forward now will be answered, where it is humanly possible, in the not-too-distant future.

Again, I say you all ought to be proud to belong to the finest profession in the world. There is none to compare with it.

I wish to thank you, General Hartgill and Brigadier Edwards, on behalf of my colleagues, for the privilege of meeting with you on problems which are the concern of all of us.

I wish you all God-speed back to your stations, and hope this war ends very soon.

Saturday, 17<sup>th</sup> February, 1945

MORNING SESSION

*Presiding :*

Brigadier H. C. Edwards

A meeting of Consultants and Officers i/c Divisions, Senior Surgical Specialists, and Officers i/c of Special Units was held. Major-General D.C. Monro, Major-General P.H. Mitchiner, Brigadier W. Rowley Bristow and Brigadier C. Naunton Morgan also attended.

The two main topics for discussion were post-graduate teaching in Italy, and the relations between RAMC and EMS medical officers.

(a) *Post-graduate teaching in Italy.*

The meeting was unanimously of the opinion that post graduate courses should be organised at an early date at various Centres on the Continent. The object of the courses is primarily to assist medical officers who are working with field units or who hold administrative appointments.

(b) *Relations between RAMC and EMS medical officers.*

The meeting expressed its keen approval of the consideration now being given by the authorities at home to the possibility of arranging exchanges between RAMC and EMS medical officers.



## *Delegates*

### BRITISH

Lieut. P. ALEXINSKI  
Major H. F. ANDERSON  
Brigadier S. ARNOTT  
Lt.-Col. P. B. ASCROFT  
Major D. W. ASHCROFT  
Lt.-Col. H. J. B. ATKINS  
Major J. B. BAMFORD  
Major R. J. V. BATTLE  
Major P. H. BEATTIE  
Major R. L. BENISON  
Capt. F. BERNSTEIN  
Major J. G. BICKERTON  
Major G. BLACKBURN  
Brigadier E. R. BOLAND  
Lt.-Col. T. F. BRIGGS  
Brigadier W. R. BRISTOW  
Lt.-Col. W. S. BRINDLE  
Lt.-Col. J. J. M. BROWN  
Capt. L. S. BRUCE  
Major H. W. BURGE  
Major R. J. BUXTON  
Capt. K. P. S. CALDWELL  
Brigadier W. M. CAMERON  
Lt.-Col. W. M. CAPPER  
Major A. R. CLARK  
Capt S. H. C. CLARKE  
Major P. CLARKSON  
Major G. J. CLELAND  
Major D. J. COLLIER  
Major R. COX  
Lt.-Col. R. COYTE  
Major W. V. CRUDEN  
Lt.-Col. A. L. d'ABREU  
Capt. G. G. DONALDSON  
Major H. G. ESTCOURT  
Major G. H. EAGLES  
Lt.-Col. A. ELLIOT-SMITH  
Major G. D. FALCONER  
Capt. T. FAULKNER  
Lt.-Col. G. Y. FEGGETTER  
Major E. A. FIDDIAN  
Lt.-Col. J. FLEMING  
Major R. J. FURLONG  
Major R. S. GARDEN  
Major S. GLASER  
Colonel F. S. GILLESPIE  
Capt. F. J. GILLINGHAM  
Lt.-Col. W. C. GLEDHILL  
Major J. C. GOLIGHER  
Capt. I. C. A. D. P. GRAHAM  
Lt.-Col. R. T. GRANT

Major W. M. GRAY  
Major R. T. GRIME  
Capt. H. HARRIS  
Major-General W. C. HARTGILL  
Lt.-Col. R. W. HENDRY  
Major T. M. HENNEBRY  
Capt P. F. J. HICKINBOTHAM  
Lt.-Col. A. R. C. HIGHAM  
Major J. HOWELL  
Colonel T. D. INCH  
Major J. A. JAMES  
Capt. J. A. JAMES  
Lt.-Col. B. R. M. JOHNSON  
Lt.-Col. D. W. JOLLY  
Major C. D. P. JONES  
Capt. R. M. S. KEIR  
Major J. G. KERR  
Capt. J. A. KEY  
Lt.-Col. J. B. KING  
Lt.-Col. R. A. KING  
Lt.-Col. A. J. C. LATCHMORE  
Lt.-Col. W. A. LAW  
Capt. R. S. LAWRIE  
Major A. R. LEASK  
Major D. K. LENNOX  
Major T. LEVITT  
Major R. S. LEWIS  
Major D. L. LEWIS  
Capt. R. W. LUSH  
Major S. N. LYTLE  
Lt.-Col. W. D. F. LYTLE  
Lt.-Col. J. A. MACDOUGALL  
Capt. C. D. T. MACLEAN  
Major W. MACLEOD  
Major A. I. S. MACPHERSON  
Capt. M. C. MACQUEEN  
Brigadier R. MARNHAM  
Lt.-Col. C. M. MARSDEN  
Lt.-Col. C. F. MAYNE  
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Major A. McDOWALL  
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Capt J. A. MCKENZIE  
Capt. T. B. McMURRAY  
Colonel J. T. McOUAT  
Capt. J. Mc. I. MEGAW  
Major W. R. MERRINGTON  
Lt.-Col. W. A. MILL  
Major-General P. H. MITCHINER  
Major-General D. C. MONRO  
Lt.-Col. T. MOORE

## *Delegates*

### **BRITISH** (*continued*)

Brigadier C. N. MORGAN  
Capt. I. P. MUNRO  
Lt.-Col. C. J. B. MURRAY  
Lt.-Col. R. W. NEVIN  
Major W. F. NICHOLSON  
Major H. D. O'BRIEN  
Capt. A. E. O'DONNELL  
Capt. C. PARISH  
Lt.-Col. D. S. POOLE-WILSON  
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Major C. G. ROB  
Major G. K. T. ROCHE  
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Major J. RYDER  
Colonel H. L. SHEEHAN  
Major J. SHORESTON  
Major H. H. SKEOCH  
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Lt.-Col. J. R. St. G. STEAD  
Major B. B. STIMSON  
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Colonel G. G. TALBOT  
Major O. H. J. M. TELLING  
Major S. THOMSON  
Major R. THORNLEY  
Major C. P. K. TOLAND  
Major W. S. TULLOCH  
Capt. J. TULLOCH-BROWN  
Capt. G. K. TUTTON  
Major H. D. S. VELLACOTT  
Capt. A. J. WALKER  
Capt. A. S. WALKER  
Capt. W. K. J. WALLS  
Lt.-Col. A. J. WATSON  
Lt.-Col. A. S. WESSON  
Lt.-Col. G. E. W. WOLSTENHOLME  
Major G. H. WOOLER  
Colonel T. YOUNG  
Major A. YOUNG

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Surg/Lt. E. F. CHIN  
Surg/Lt. Cdr. M. R. EWING  
Surg/Lt. S. MELECK  
Surg/Capt. C. B. NICHOLSON  
Surg/Lt. Cdr. R. NICKS

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S/Ldr. A. M. ABRAHAMS  
W/Cdr. B. J. BICKFORD  
Air/Cdr. T. K. LYLE  
W/Cdr. D. F. NASH  
S/Ldr. N. VERE-HODGE

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Lt.-Col. Marshall K. BARTLETT  
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Lt.-Col. John R. PAINE  
Lt.-Col. Langdon PARSONS  
Capt. Fred PEASE  
Major Robert W. ROBERTSON



## *Delegates*

### **AMERICAN** (*continued*)

Lt.-Col. Horatio ROGERS  
Capt. Abraham M. RUBINOWITZ  
Lt.-Col. Sigurd C. SANDZEN  
Lt.-Col. Paul W. SANGER  
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Colonel D. J. DU PLESSIS  
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Capt. C. GOLDBERG  
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Lt.-Col. G. L. G. MAJOR  
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Major W. SIMPSON  
Lt.-Col. M. K. TUCKER  
Lt.-Col. H. C. WARNER

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Lt.-Col. D. BHATIA  
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Major J. DONOVAN  
Capt. R. H. P. FITZPATRICK  
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Colonel M. KIRK BRYCE  
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Major R. H. NEEVE  
Major S. C. SARKHEL  
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Lt.-Col. A. G. CLARK  
Lt.-Col. E. Y. COMRIE  
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Capt. F. HODGKISS  
Brigadier H. S. KENRICK  
Capt. W. M. MACLAURIN  
Major D. P. O'BRIEN  
Major G. F. RICH  
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Capt. J. BALK  
2/Lieut W. BIELECKI  
2/Lieut L. BIEBERSTEIN  
Major M. KLEPACZ  
Major A. KIELBINSKI  
2/Lieut A. MAJEWSKI  
Major C. MACIEJEWSKI  
2/Lieut F. PLOSZAJ  
Colonel T. SOKOŁOWSKI  
Lieut M. SKORCZYŃSKI  
Lt.-Col. A. SOLTYSIK  
Lieut Z. SALACINSKI  
Lieut A. WALEWSKI  
Major A. WASILEWSKI  
2/Lieut M. WEINTAL







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